Gratitude

In appreciation and gratitude
to The Custodian of the Two Holy Mosques

King Abdullah Bin Abdul Aziz Al Saud

And

H.R.H. Prince Sultan Bin Abdul Aziz Al Saud

Crown Prince, Deputy Premier, Minister of Defence
& Aviation and Inspector General

For their continuous support and gracious consideration,
the Saudi Building Code National Committee (SBCNC)
is honored to present the first issue of
the Saudi Building Code (SBC).

Saudi Building Code Requirements

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PREFACE

The Saudi Building Code (SBC) is a set of legal, administrative and technical regulations and requirements that specify the minimum standards of construction for building in order to ensure public safety and health. A Royal Decree dated 11th June 2000 order the formation of a national committee composed of representatives of Saudi universities and governmental and private sectors. In September 2001, the Council of Ministers approved the general plan of the National Committee to develop a national building code for the Kingdom of Saudi Arabia.

To choose a base code for the Saudi Building Code, a number of Codes have been studied. The National Committee has been acquainted with the results of the national researches and the international codes from the U.S.A., Canada and Australia, also, the European Code, and Arab Codes. It has also sought the opinions of specialists in relevant Saudi universities, governmental and private sectors through holding a questionnaire, a symposium and specialized workshops, in the light of which, (ICC) has been chosen to be a base code for the Saudi Building Code. It has also endorsed the use of the International Electrotechnical Commission (IEC) in respect of the electrotechnical regulations and requirements.

Toward expanding the participation of all the specialists in the building and construction industry in the Kingdom through the governmental and private sectors, the universities and research centers, the National Committee took its own decisions related to code content by holding specialized meetings, symposiums and workshops and by the help of experts from inside and outside of Saudi Arabia.

The technical committees and sub-committees started their work in the beginning of April 2003 to develop the Saudi Building Code that adapts the base code with the social and cultural environment, the natural and climatic conditions, types of soil and properties of materials in the Kingdom

The Saudi Building Code Electrical Requirements (SBC 401) were developed based on the standards of the Saudi Arabian Standards Organization (SASO) which in turn based on the International Electrotechnical Standards Series of IEC 60364 (Electrical Installations of Buildings).

The purpose of SBC 401 is to provide minimum requirements to safeguard life, health, properties and public welfare by regulating and controlling the design, installation, and use of electrical systems and equipment in the buildings at the Kingdom of Saudi Arabia. It covers construction, location, operation, repairs, addition and replacement. In addition to safety aspects, these Electrical Requirements deal with basic principles and requirements for the design and installation of some special systems.

The Numbering System of these Electrical Requirements contains some unused (void) numbers among the normal sequence of Sections, Sub-Sections, Statements or Sub-Statements. For example, Chapter 55 is composed of Sections 55-1, 55-6, 55-7, 55-8 and 55-9, while Sections 55-2, 55-3, 55-4 and 55-5 are not present, where void numbers inside this Code are reserved for future expansion.

The Numbering System of these Electrical Requirements is different from the one used in IEC. The various components of the SBC 401, except that of special chapters of the electrical requirements, are identified as follows:

1. **Chapters**: Numbered sequentially in two digits, starting from chapter 11. e.g., (11, 21, 44, 53)
2. **Sections**: Sequentially within each chapter by the chapter number followed by a dash and then a section number of a single digit, e.g., (41-3, 44-4, 54-1)
3. **Sub-Sections:** Sequentially within each section by the section number followed by a point and then a number from one or two digits, e.g., (13-2.11, 52-8.2)
4. **Sub-sub-section:** Sequentially within each sub-section by the sub-section number followed by a further point and then a number from one or two digits, e.g., (13-1.2.1, 53-4.2.10)
5. **Statement**: Sequentially within each sub-sub-section by the sub-sub-section number followed by a further point and a statement number from one or two digits, e.g., (44-3.3.2.1, 55-1.4.4.2)
6. **Sub-statement:** Sequentially within each statement by the statement number followed by a further point and a sub-statement number from one or two digits, e.g., (44-3.3.2.1.2, 55-1.4.4.2.1)
7. **Tables and figures**: By the chapter number to which they belong, followed by a dash then a sequential number from one or two digits, e.g., (Table 52-3, Figure 44-5)
8. **Annexes:** By a capital letter, followed by a dot point and then by the chapter number to which they belong, e.g., (Annex A.44, Annex C.55)
9. **Tables and figures inside an annex:** By the annex id (letter + chapter number) to which they belong followed by a dash then a sequential number from one or two digits, e.g., (Figure B.52-11, Table A.44-3)

Special Chapters of the Saudi Building Code Electrical Requirements SBC 401, are identified as follows:

1. **Special Chapters**: Numbered sequentially in three digits, starting from chapter 701, e.g., (701, 760, 803)
2. **Reference to general chapters**: By the number of the special chapter followed by a colon and then the number of corresponding chapters, sections, sub-sections or statements of SBC 401 to refer to, e.g., (701:41-1.1.3.7 740:52-1.6)
3. **Sections**: Sequentially within each chapter by the chapter number followed by a dash and then a section number of a single digit, e.g., (01-3, 802-4)
4. **Sub-Sections**: sequentially within each section by the section number followed by a point and then a number from one or two digits, e.g., (801-3.1, 802-4.3)
5. **Sub-sub-section**: Sequentially within each sub-section by the sub-section number followed by a further point and then a number from one or two digits, e.g., (801-3.1.2)
6. **Statement**: Sequentially within each sub-sub-section by the sub-sub-section number followed by a further point and a statement number from one or two digits, e.g., (801-3.1.2.1)
7. **Sub-statement**: Sequentially within each statement by the statement number followed by a further point and a sub-statement number from one or two digits, e.g., (801-3.1.2.1.2)
8. **Tables and figures**: By the chapter number to which they belong, followed by a dash then a sequential number from one or two digits, e.g., (Table 701-3, Figure 801-1)

9. **Annexes**: By a capital letter, followed by a dot point and then by the chapter number to which they belong, e.g., (Annex A.708, Annex C.802)
10. **Tables and figures inside an annex**: By the annex id (letter + chapter number) to which they belong followed by a dash then a sequential number from one or two digits, e.g., (Figure B.710-1, Table A.708-3).

The development process of SBC 401 followed the methodology approved by the Saudi Building Code National Committee. Many changes and modifications were made on the base code. The changes were intended to compose a comprehensive set of provisions, to the best possible extent, for materials, environmental conditions, and construction practices prevailing in the Kingdom.

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PART ONE

SCOPE AND FUNDAMENTAL PRINCIPLES

CHAPTER 11
SCOPE

11-0.1 This SBC 401 applies to electrical installations such as those of:

a) residential premises;
b) commercial premises;
c) public premises;
d) industrial premises;
e) agricultural and horticultural premises;
f) prefabricated buildings;
g) camping sites, tents caravans, and similar sites;
h) construction sites, exhibitions, fairs and other temporary installations;
i) marinas and pleasure craft;
j) hazardous locations.

11-0.2 This SBC 401 covers:

a) circuits supplied at nominal voltages up to and including 1000 V a.c. or 1500 V d.c.;
b) for a.c., the frequency, which is taken into account in this code, is 60 Hz. The use of other frequencies, for special purposes, is not excluded;
c) circuits, other than the internal wiring of apparatus, operating at voltages exceeding 1000 V and derived from an installation having a voltage not exceeding 1000 V a.c., e.g. electric signs, discharge lighting, electrostatic precipitators;
d) any wiring systems and cables not specifically covered by the standards for appliances;
e) all consumer installations external to the buildings;
f) fixed wiring for telecommunications, signaling, control and the like (excluding internal wiring of apparatus);
g) the extension or alteration of the installation and also parts of the existing installation affected by the extension or alteration;
h) safety lighting circuits;
i) electric sign and outline lighting;
j) fire detection and alarm systems;
k) lightning protection systems;
l) power factor improvement systems;
m) electric appliances;
n) electric lifts and escalators.

11-0.3 The SBC 401 (Electrical Requirements) does not apply to:

a) electric traction equipment;
b) electrical equipment of motor vehicles;
c) electrical installations on board ships, mobile and fixed offshore platforms;
d) electrical installations in aircraft;
e) public street-lighting installations which are supplied from the public power network;
f) electrical installations in mines and quarries;
g) radio interference suppression equipment, except so far as it affects safety of the installation;
h) electric fences.

11-0.4 These Electrical Requirements are not intended to apply to:

- systems for distribution of energy to the public, or
- power generation and transmission for such systems.

11-0.5 Electrical equipment is dealt with only as far as its selection and application in the installation are concerned.

This applies also to assemblies of electrical equipment complying with the relevant standards.

11-0.6 An assessment is made of the following characteristics of the installation in accordance with the chapter indicated:

- the purposes for which the installation is intended to be used, its general structure and its supplies (Chapter 31);
- the external influences to which it is to be exposed (Chapter 51);
- the compatibility of its equipment (Chapter 32);
- its maintainability (Chapter 32).

Those characteristics shall be taken into account in the choice of methods of protection for safety (see Chapter 41 to Chapter 44) and the selection and erection of equipment (see Chapter 51 to Chapter 55).

NOTE For telecommunications installations, account should be taken of any Saudi Standards as well as publications of the CCIT (Commission of Communications and Information Technology) relevant to the type of installation concerned.

CHAPTER 12
FUNDAMENTAL PRINCIPLES

12-1 Protection for safety

12-1.1 General

The requirements stated in this section are intended to ensure the safety of persons, livestock and property against dangers and damage, which may arise in the reasonable use of electrical installations.

NOTE In electrical installations, four major types of risk exist:

- shock currents;
- excessive temperatures likely to cause burns, fires and other injurious effects.
- Mechanical movement of electrically actuated equipment, and so far as such injury is intended to be prevented by electrical emergency switching or by electrical switching for mechanical maintenance of non-electrical parts of such equipments.
- explosion.

12-1.2 Protection against electric shock

12-1.2.1 Protection against direct contact

Persons and livestock shall be protected against dangers that may arise from contact with live parts of the installation.

This protection can be achieved by one of the following methods:

- preventing a current from passing through the body of any person or any livestock;
- limiting the current which can pass through a body to a value lower than the shock current.

12-1.2.2 Protection against indirect contact

Persons and livestock shall be protected against dangers that may arise from contact with exposed-conductive-parts in case of a fault.

This protection can be achieved by one of the following methods:

- preventing a fault current from passing through the body of any person or any livestock;
- limiting the fault current which can pass through a body to a value lower than the shock current;
- automatic disconnection of the supply in a determined time on the occurrence of a fault likely to cause a current to flow through a body in contact with exposed-conductive-parts, where the value of that current is equal to or greater than the shock current.

NOTE In connection with the protection against indirect contact, the application of the method of equipotential bonding is one of the important principles for safety.

12-1.3 Protection against thermal effects

The electrical installation shall be so arranged that there is no risk of ignition of flammable materials due to high temperature or electric arc. In addition, during normal operation of the electrical equipment, there shall be no risk of persons or livestock suffering burns.

12-1.4 Protection against overcurrent

Persons or livestock shall be protected against injury and property shall be protected against damage due to excessive temperatures or electromechanical stresses caused by any overcurrents likely to arise in live conductors.

This protection can be achieved by one of the following methods:

- automatic disconnection on the occurrence of an overcurrent before this overcurrent attains a dangerous value taking into account its duration;

- limiting the maximum overcurrent to a safe value and duration.

12-1.5 Protection against fault currents

Conductors, other than live conductors, and any other parts intended to carry a fault current shall be capable of carrying that current without attaining an excessive temperature.

NOTE 1 Particular attention should be given to earth fault currents and leakage current.

NOTE 2 For live conductors, compliance with 12-1.4 assures their protection against overcurrents caused by faults.

12-1.6 Protection against voltage disturbances and measures against electromagnetic influences

12-1.6.1 The installation shall have an adequate level of immunity against electromagnetic disturbances for correct functioning in the given environment. Any generated electromagnetic emission shall not exceed a level non-compatible to envisaged environment.

12-1.6.2 Persons or livestock shall be protected against injury and property shall be protected against any harmful effects as a consequence of a fault between live parts of circuits supplied at different voltages.

12-1.6.3 Persons or livestock shall be protected against injury and property shall be protected against damage as a consequence of any excessive voltages likely to arise due to other causes (e.g. atmospheric phenomena or switching overvoltages).

12-1.6.4 Where a drop in voltage, or a loss and subsequent restoration of voltage could imply dangerous situations for persons or property, suitable precautions shall be taken into account. Also, precautions shall be taken where a part of the installation or current-using equipment may be damaged by a drop in voltage.

12-2 Design

12-2.1 General

For the design of the electrical installation, the factors in the following statements (12-2.2 to 12-2.12) shall be taken into account to provide:

- the protection of persons, livestock and property in accordance with 12-1;
- the proper functioning of the electrical installation for the use intended.

The information required as a basis for design is listed in 12-2.2 to 12-2.5. The requirements with which the design should comply are stated in 12-2.6 to 12-2.12.

12-2.2 Characteristics of available supply or supplies

Information on the characteristics of the available supplies as below shall be determined by calculation, measurement, enquiry or inspection.

NOTE Where in these Electrical Requirements, the terms a.c. voltage and a.c. current are used, they imply r.m.s. values unless otherwise specified.

12-2.2.1 Nature of current: a.c. and/or d.c.

12-2.2.2 Nature and number of conductors:

- For a.c.: phase conductor(s);
  neutral conductor;
  protective conductor.
- For d.c.: conductors equivalent to those listed above.

12-2.2.3 Values and tolerances:

- voltage and voltage tolerances;
- frequency and frequency tolerances;

- maximum current allowable;
- prospective short-circuit current.

12-2.2.4 Protective measures inherent in the supply, e.g. earthed (grounded) neutral or mid-wire.

12-2.2.5 Particular requirements of the supply undertaking.

12-2.3 Nature of demand

The number and type of circuits required for lighting, heating, HVAC, power, control, signaling, information and communication technology, etc. are to be determined by:

- location of points of power demand;
- loads to be expected on the various circuits;
- daily and yearly variation of demand;
- any special conditions;
- requirements for control, signaling, telecommunication and information technology, etc.

12-2.4 Electric supply systems for safety services or standby electric supply systems

- Source of supply (nature, characteristics);
- Circuits to be supplied by the electric source for safety services or the standby electrical source.

12-2.5 Environmental conditions

See 51-2.2 of Chapter 51.

12-2.6 Cross-section of conductors

The cross-section of conductors shall be determined according to the maximum continuous current-carrying capacities in addition to the following:

a) their admissible maximum temperature;
b) the admissible voltage drop;
c) the electromechanical stresses likely to occur due to short-circuits;
d) other mechanical stresses to which the conductors can be exposed;
e) the maximum impedance with respect to the functioning of the protection against fault currents.

NOTE The above listed items concern primarily the safety of electrical installations, cross-sectional areas greater than those required for safety may be desirable for economic operation.

12-2.7 Type of wiring and methods of installation

The choice of the type of wiring and the methods of installation depend on:

- the nature of the locations;
- the nature of the walls or other parts of the building supporting the wiring;
- accessibility of wiring to persons and livestock;
- voltage;
- the electromechanical stresses likely to occur due to short-circuits;
- other stresses to which the wiring can be exposed during the erection of the electrical installation or in service.

12-2.8 Protective equipment

The characteristics of protective equipment shall be determined with respect to their function, which may be, e.g., protection against the effects of:

- overcurrent (overload, short-circuit);
- earth fault current;
- overvoltage;
- undervoltage and no-voltage.

The protective devices shall operate at values of current, voltage and time, which are suitably related to the characteristics of the circuits and to the possibilities of danger.

12-2.9 Emergency control

Where, in case of danger, there is a necessity for immediate interruption of supply, an interrupting device shall be installed in such a way that it can be easily recognized and effectively and rapidly operated.

12-2.10 Disconnecting devices

Disconnecting devices shall be provided so as to permit disconnection of the electrical installation, circuits or individual items of apparatus as required for maintenance, testing, fault detection or repair.

12-2.11 Prevention of mutual influence

The electrical installation shall be arranged in such a way that no mutual detrimental influence will occur between the electrical installation and non-electrical installations of the building.

12-2.12 Accessibility of electrical equipment

The electrical equipment shall be arranged so as to afford as may be necessary:

- sufficient space for the initial installation and later replacement of individual items of electrical equipment;
- accessibility for operation, testing, inspection, maintenance and repair.

12-3 Selection of electrical equipment

12-3.1 General

Every item of electrical equipment used in electrical installations shall comply with the relevant Saudi standards as are appropriate. In the absence of Saudi standards, the equipment shall comply with the appropriate international standards (IEC, ISO, or ITU). Where there are no applicable standards the item of equipment concerned shall be selected by special agreement between the person specifying the installation and the installer.

12-3.2 Characteristics

Every item of electrical equipment selected shall have suitable characteristics appropriate to the values and conditions on which the design of the electrical installation (see 12-2) is based on and shall, in particular, fulfill the following requirements.

12-3.2.1 Voltage

Electrical equipment shall be suitable with respect to the maximum steady voltage (r.m.s. value for a.c.) likely to be applied, as well as overvoltages likely to occur.

NOTE For certain equipment, it may be necessary to take account of the lowest voltage likely to occur.

12-3.2.2 Current

All electrical equipment shall be selected with respect to the maximum steady current (r.m.s. value for a.c.) which it has to carry in normal service, and with respect to the current likely to be carried in abnormal conditions and the period (e.g. operating time of protective devices, if any) during which it may be expected to flow.

12-3.2.3 Frequency

If frequency has an influence on the characteristics of electrical equipment, the rated frequency of the equipment shall correspond to the frequency likely to occur in the circuit.

12-3.2.4 Power

All electrical equipment, which is selected on the basis of its power characteristics, shall be suitable for the duty demanded of the equipment, taking into account the load factor and the normal service conditions.

12-3.3 Conditions of installation

All electrical equipment shall be selected so as to withstand safely the stresses and the environmental conditions (see 12-2.5) characteristic of its location and to which it may be exposed to. If, however, an item of equipment does not have by design the properties corresponding to its location, it may be used on condition that adequate additional protection is provided as part of the completed electrical installation.

12-3.4 Prevention of harmful effects

All electrical equipment shall be selected so that it will not cause harmful effects on other equipment or impair the supply during normal service including switching operations. In this context, the factors, which can have an influence, include:

- power factor;
- inrush current;
- asymmetrical load;
- harmonics.

12-4 Erection and verification of electrical installations

12-4.1 Erection

12-4.1.1 For the erection of the electrical installation, good workmanship by suitably qualified personnel and the use of proper materials shall be provided for.

12-4.1.2 The characteristics of the electrical equipment, as determined in accordance with 12-3, shall not be impaired in the process of erection.

12-4.1.3 Conductors shall be identified in accordance with these Electrical Requirements and SASO IEC 60446.

12-4.1.4 Connections between conductors and between conductors and other electrical equipment shall be made in such a way that safe and reliable contact is ensured.

12-4.1.5 All electrical equipment shall be installed in such a manner that the designed cooling conditions are not impaired.

12-4.1.6 All electrical equipment likely to cause high temperatures or electric arcs shall be placed or guarded so as to eliminate the risk of ignition of flammable materials. Where the temperature of any exposed parts of electrical equipment is likely to cause injury to persons, those parts shall be so located or guarded as to prevent accidental contact therewith.

12-4.2 Verification

Electrical installations shall be tested and inspected before being placed in service and after any important modification to verify proper execution of the work in accordance with these Electrical Requirements (see PART SIX).

12-4.3 Periodic verification

The person carrying out inspection and testing shall make a recommendation for subsequent periodic inspection and testing as detailed in Annex G.61 of PART SIX.

PART TWO

DEFINITIONS

CHAPTER 21
DEFINITIONS

This chapter contains a brief definition of each of the selected vocabularies mentioned in these Electrical Requirements.

(A)

Accessibility of equipment
Every piece of equipment which, requires operation or attention by a person shall be installed that adequate and safe means of access and working space are afforded for such operation or attention.

Accessory
A device, other than current-using equipment, associated with an equipment or with the wiring of an installation.

Active power
The delivered power that is used or converted to a useful power or is dissipated in the form of heat by a network or system.

Air terminal (for lightning protection)
A strike termination device that is essentially a point receptor for attachment of flashes to the lightning protection system. Typical air terminals are formed of a tube or solid rod. Air terminals are sometimes called lightning rods.

Ambient temperature
The temperature of the air or other medium where the equipment is to be used.

Amusement device
Ride, stand, textile or membrane building, side stall, side show, tent, booth, grandstand intended for the entertainment of the public.

Apparent power
The power delivered to a load without consideration of the effects of a power factor angle of the load. It is determined solely by the product of the terminal voltage and current of the load.

Appliance
Any device which utilizes electricity for a particular purpose, excluding a lighting fitting or an independent motor.

Approved
Acceptable to the authority having jurisdiction or accreditation.

Arm's reach
A zone extending from any point on a surface where persons usually stand or move about, to the limits, which a person can reach with the hand in any direction without assistance, e.g. from tools or from a ladder.

Associated apparatus (in hazardous locations)
Electrical apparatus in which the circuits or parts of circuits are not all necessarily intrinsically safe but which contains circuits that can affect the safety of the intrinsically safe circuits associated with it.

Automatic disconnection of supply
Interruption of one or more of the line conductors, affected by the automatic operation of a protective device in case of a fault.

(B)

Barrier
A part providing protection against direct contact from any usual direction of access.

Basic insulation
Insulation applied to live parts to provide basic protection against electric shock and which does not necessarily include insulation used exclusively for functional purposes.

Basic protection
For low-voltage installations, systems and equipment protection against electric shock under fault-free conditions, and generally corresponds to protection against direct contact.

Basic safety insulation
The insulation necessary for basic protection against electric shock, and for the proper functioning of equipment.

Basin of fountain
Basin not intended to be occupied by persons.

Bonding
An electrical connection between an electrically conductive object and a component of a lightning protection system that is intended to significantly reduce potential differences created by lightning currents.

Bonding bar
Bar by means of which the bonding conductors are interconnected (mutually connected).

Bonding conductor
A conductor intended to be used for potential equalization between earthed metal bodies and the lightning protection system.

Booth
Unit, usually movable, intended to accommodate equipment generally for pleasure or demonstration purposes.

Breaking current capacity
A value of current that a protective device is capable of breaking at a specified voltage and under prescribed conditions of use and operation.

Building void
A space within the structure or the components of building which can be accessible only at certain points.

(C)

Cable
A conductor formed of a number of wires stranded together.

Cable channel
An enclosure situated above or in the ground, ventilated or closed, and having dimensions which do not permit the access of persons but allow access to the conduits and/or cables throughout their length during and after installation. A cable channel may or may not form part of the building construction.

Cable coupler
A means enabling the connection, at will of two flexible cables. It consists of a connector and a plug.

Cable ducting
An enclosure of metal or insulating material, other than conduit or cable trunking, intended for the protection of cables, which are drawn-in after erection of the ducting.

Cable ladder
A cable support consisting of a series of transverse supporting elements rigidly fixed to main longitudinal supporting members.

Cable tray
A cable support consisting of a continuous base with raised edges and no covering. A cable tray may or may not be perforated.

Cable trunking
A closed enclosure normally of rectangular cross-section, of which one side is removable or hinged, used for the protection of cables and for the accommodation of other electrical equipment.

Cable tunnel
A corridor containing supporting structures for cables and joints and/or other elements of wiring systems and whose dimensions allow persons to pass freely throughout the entire length.

Capacitor
A fundamental electrical element having two conducting surfaces separated by an insulating material and having the capacity to store charge on its plates.

Caravan
Trailer leisure accommodation vehicle, used for touring, housing, offices and temporary construction that meet requirements for construction and use of road vehicles.

Caravan Park
Area of land that contains two or more caravan pitches.

Caravan pitch
Plot of earth upon which a single leisure accommodation vehicle or leisure home stands.

Caravan pitch electrical supply equipment
Equipment that provides means of connecting and disconnecting supply cables from leisure accommodation vehicles or leisure homes with a mains electric supply.

Catenary lightning protection system
A lightning protection system consisting of one or more overhead earth wires. Each overhead earth wire forms a catenary between masts and serves the functions of both a strike termination device and a main conductor.

Certificate of conformity
A specified duration certificate should be issued by the contractor through accredited body to confirm the electrical installation as per the Saudi Building Code requirements and related to the test report results given by the inspection body.

Chimney (of lightning protection)
A smoke or vent stack having a flue with a cross-sectional area less than 0.3 m^2 and a total height of 23 m or less.

Circuit breaker
A mechanical device capable of making and carrying currents under normal circuit conditions and also capable of breaking currents under specified abnormal circuit conditions such as those of short-circuits.

Circuit protective conductor
A protective conductor connecting exposed-conductive-parts of equipment to the main earthing terminal.

Class I equipment
Equipment having basic insulation throughout, and depending on earthing of exposed conductive parts for protection against indirect contact in the event of failure of the basic insulation.

Class I flammable Liquid (of lightning protection)
A liquid having a flash point below 37.8°C and having a vapour pressure not exceeding 275 kPa at 37.8°C. Class I liquids shall be subdivided as follows:

- **a)** Class IA shall include those having flash points below 22.8°C and having a boiling point below 37.8°C.
- **b)** Class IB shall include those having flash points below 22.8°C and having a boiling point at or above 37.8°C.
- **c)** Class IC shall include those having flash points at or above 22.8°C and below 37.8°C.

Class I materials (of lightning protection)
Lightning conductors, air terminals, earth terminals, and associated fittings for the protection of structures not exceeding 23 m in height.

Class II equipment
Equipment having double insulation or reinforced insulation, or a combination of these throughout, and whose intermediate parts are protected by supplementary insulation so that there is no risk of indirect contact in the event of failure of basic insulation. Class II equipment is marked with the symbol ⧈.

Class II materials (of lightning protection)
Lightning conductors, air terminals, earth terminals, and associated fittings for the protection of structures exceeding 23 m in height.

Class III equipment
Equipment which will not give rise to electric shock because it is designed for supply from Isolated Extra Low-voltage (IELV) only and in which voltages higher than those of IELV are not generated. This equipment is normally not earthed by the provision of earthing facilities and does not necessarily exclude any such equipment from being regarded as Class III equipment.

Clearance (Creepage Distance)
The shortest distance between two conductive parts or between a live part and an accessible surface of an enclosure, earthed metalwork or flammable materials, measured through the air.

Combination wave (of SPD)
Waveform delivered by a generator that applies a 1.2/50 voltage impulse across an open circuit and an 8/20 current impulse into a short-circuit.

Combined multi-port SPD
Surge protective device (SPD) integrating in a single package the means for providing surge protection at two or more ports of equipment connected to different systems, such as a power system and a communications system.

Combustible liquid
A liquid having a flash point at or above 37.8°C. Combustible liquids shall be subdivided as follows:

a) Class II liquids shall include those having flash points at or above 37.8°C and below 60°C.
b) Class IIIA liquids shall include those having flash points at or above 60°C and below 93°C.
c) Class IIIB liquids shall include those having flash points at or above 93°C.

Conductive screen (shield)
Conductive part that encloses or separates electric circuits and/or conductors.

Conduit
Tubing intended for enclosing cables and wires in order to protect them from mechanical damage.

Contactor
A contactor is a mechanical device usually intended to operate frequently and having only one position of rest, operated electromagnetically, capable of making, carrying, and breaking currents under normal circuit conditions, including operating overload conditions.

Continuous dilution (flow)
Continuous supply of a protective gas, after purging, at such a rate that the concentration of a flammable substance inside the pressurized enclosure is maintained at a value outside the explosive limits at any potential ignition source (that is, outside the dilution area).

Conventional non-operating current of a protective device
A specified value of current which the protective device is capable of carrying for a specified time (conventional time) without operating. For fuses, this current is called the "conventional non-fusing current" For circuit breakers this current called the "conventional non-tripping current".

Conventional operating current of a protective device
A specified value of the current, which causes the protective device to operate within a specified designated conventional time.

Conventional touch voltage limit
Maximum value of the touch voltage, which is permitted to be maintained indefinitely in specified conditions of external influences.

Converter
Unit for the electronic conversion of an a.c. supply at one frequency to an a.c. supply at another frequency. The voltage may be or may not be altered during the conversion.

Coordination of SPDs
Selection of characteristics for two or more SPDs (Surge Protection Device) to be connected across the same conductors of a system but separated by some decoupling impedance such that, given the parameters of the impedance and of the impinging surge, this selection will ensure that the energy deposited in each of the SPDs is commensurate with its rating.

Copper-clad steel
Steel with a coating of copper bonded to it.

Counterweight (of a Lift)
A weight or a series of weights, serving to counter balance the weight of the lift car together with a part of the rated load.

Creepage distance (clearance)
Shortest path between two conductive parts or between a live part and an accessible surface of an enclosure, earthed metal work or flammable materials, measured along the surface of the insulation material.

Current-carrying capacity (ampacity) of a conductor
The maximum value of current, which can be carried continuously by a conductor under specified conditions without its steady-state temperature exceeding a specified value.

Current-operated earth-leakage circuit breaker
A mechanical device capable of automatically disconnecting a circuit from the supply when the earth fault current in the circuit exceeds a specified value.

Current-using equipment
Equipment intended to convert electrical energy into another form of energy, for example light, heat, motive power.

(D)

Danger zone
In the case of high voltage, area limited by the minimum clearance around hazardous-live-parts without complete protection against direct contact. Entering the danger zone is considered as the same as touching hazardous-live-parts.

Data processing equipment
Electrically operated machine units that, separately or assembled in systems, accumulate, process and store data.

Demand factor
The ratio expressed as a numerical value or as a percentage of the maximum demand of an installation or a group of installations within a specified period, to the corresponding total installed load of the installation(s).

Design current (of a circuit)
The current intended to be carried by a circuit in normal service.

Differential current
The vectorial sum, (measured simultaneously), of the currents in the supply conductors of an electrical circuit.

Direct contact
Contact of persons or livestock with live parts.

Disconnector
A mechanical switching device which, in the open position, complies with the requirements specified for isolation. A disconnector is otherwise known as an isolator.

Distribution board
An assembly of protective devices, including one or more fuses or circuit-breakers, arranged for the distribution of electrical energy to final sub-circuits or to other distribution boards.

Distribution circuit
A circuit supplying a distribution board.

Double insulation
Insulation comprising both basic safety insulation and supplementary insulation.

Duct
A closed passageway formed underground or in a structure through which cables may be installed.

(E)

Earth (ground)
The conductive mass of the earth whose electric potential at any point is conventionally taken as equal to zero.

Earth electrode
One or more conductive parts embedded in the earth for the purpose of making effective electrical contact with the general mass of earth. It can be conductive part, which may be embedded in a specific conductive medium, e.g. concrete or coke, in electric contact with earth.

Earth electrode resistance
The resistance of an earth electrode to earth.

Earth equipotential zone
A zone within which exposed conductive parts and extraneous conductive parts are maintained at substantially the same potential by bonding such that, under fault conditions, the difference in potential between simultaneously accessible exposed and extraneous conductive parts will not cause electric shock.

Earth fault
A conductive part or a group of conductive parts in an intimate contact with and providing an electrical connection with earth.

Earth fault loop impedance
The impedance of the earth fault current loop starting and ending at the point of earth fault. This impedance is denoted by the symbol Z_s.

Earthing
Connection of the exposed conductive parts of an installation to the main earthing terminal of the installation.

Earthing arrangement
all the electric connections and devices involved in the earthing of a system, an installation and equipment. This could be a locally limited arrangement of interconnected earth electrodes on the high-voltage side.

Earthing conductor
A protective conductor connecting the main earthing terminal or bar to the earth electrode.

Earthing Systems
An electrical system consisting of a single source of electrical energy and an installation. For certain purposes, of the Regulations, types of systems are identified as follows, depending upon the relationship of the source, and of exposed conductive parts of the installation, to Earth:

> **TN system:** a system having one or more points of the source of energy directly earthed, the exposed conductive parts of the installation being connected to that point by protective conductors.
>
> **TN-C system:** a system in which the neutral and protective functions are combined in a single conductor throughout the system.

TN-S system: a system having separate neutral and protective conductors throughout the system.
TN-C-S system: a system in which neutral and protective functions are combined in a single conductor in part of the system.
TT system: A system having one point of the source of energy directly earthed, the exposed conductive parts of the installation being connected to earth electrodes electrically independent of the earth electrodes of the source.
IT system: A system having no direct connection between live parts and Earth, the exposed conductive parts of the electrical installation are being earthed.

Earth leakage current
A current, which flows to earth or to extraneous conductive parts in a circuit, which is electrically sound. This current may have a capacitive component including that resulting from the deliberate use of capacitor.

Earth-leakage protective device
Device which will remove the output power from one or more transformer(s), inverter(s) or converter(s) in the event of a short-circuit between any relevant part of the output circuit and earth.

Efficiency of a LPS
The ratio of the average annual number of direct lightning flashes which cannot cause damage to the building to the direct lightning flash number to the building.

Electric circuit
An assembly of electrical equipment of the installation supplied from the same origin and protected against overcurrent by the same protective devices.

Electric shock
Pathophysiological effect resulting from an electric current passing through a human or animal body.

Electrical equipment
Any item used for such purposes as generation, conversion, transmission, distribution or utilization of electrical energy, such as machines, transformers, apparatus, measuring instruments, protective devices, equipment for wiring systems, appliances.

Electrical installation
An assembly of associated electrical equipment that fulfills a specific purpose or purposes and having coordinated characteristics.

Electrical safety source
Source intended to maintain the supply to electrical equipment essential for the safety services.

Electrically independent earth electrodes
Earth electrodes are located at such a distance from one another that the maximum current likely to traverse one of them does not significantly affect the potential of the others.

Electrically protective barrier
Part providing protection against direct contact from any usual direction of access.

Electrically protective enclosure
Electrical enclosure surrounding internal parts of equipment to prevent access to hazardous-live-part from any direction.

Electrically protective obstacle
Part preventing unintentional direct contact, but not preventing direct contact by deliberate action.

Electrically protective screen (shield)
Conductive screen (shield) used to separate an electric circuit and/or conductors from hazardous-live-parts.

Electromagnetic interference (EMI)
Degradation of the performance of an equipment, transmission channel or system caused by electromagnetic disturbance.

Emergency stopping
Emergency stopping is intended to stop a movement, which has become dangerous.

Emergency supply power system for safety services
A supply system intended to maintain the functioning of equipment essential for the safety of persons.

Emergency switching
An operation intended to remove as quickly as possible danger, which may have occurred unexpectedly.

Enclosure
A part providing protection of equipment against certain external influences and, in any direction, protection against direct contact.

Enhanced protective provision
Protective provision having a reliability of protection not less than that provided by two independent protective provisions.

Equipment protective conductor (symbol PE)
A conductor required by some measures for protection against electric shock for electrically connecting any of the following parts: exposed conductive parts, extraneous conductive parts, main earthing terminal, earth electrode, earthed point of the source or artificial neutral.

Equipotential bonding
Special electrical connections intended to bring exposed conductive parts or extraneous conductive parts to the same or approximately the same potential, but not intended to carry current in normal service.

Equipotential bonding conductor
A protective conductor for ensuring equipotential bonding.

Equipotential bonding terminal
Terminal provided on equipment or on a device and intended for the electric connection with the equipotential bonding system.

Escalator
A stairway whose steps move continuously on a circulating belt.

Escalator machinery space
A space in which the escalator machine(s) and associated equipment are spaced.

Exhibition
Event intended for the purpose of displaying and/or selling products etc., which can take place in any suitable location, either a room, building or temporary structure.

Explosive atmosphere
Mixture with air, under atmospheric conditions, of flammable substances in the form of gas, vapour, mist or dust, in which after ignition, combustion spreads throughout the unconsumed mixture.

Explosive gas atmosphere
Mixture with air, under atmospheric conditions, of flammable substances in the form of gas or vapour, in which after ignition, combustion spreads throughout the unconsumed mixture.

Explosive materials
Materials, including explosives blasting agents, and detonators, that are authorized for transportation by the legal authorities.

Exposed cable
Branch cable connected to the main circuit.

Exposed conductive part
A conductive part of electrical equipment, which can be touched and which is not normally live, but which may become live under fault conditions.

External conductive parts
External metal items entering or leaving the structure to be protected such as: pipe, network cable screen, metal ducts etc. which may carry a part of lightning current.

External influence
Any influence external to an electrical installation, which affects the design and safe operation of that installation.

Extra low-voltage (ELV)
A nominal voltage not exceeding the relevant voltage limit (50 V a.c. or 75 V d.c.) between conductors or between conductor and earth.

Extraneous conductive part
A conductive part not forming part of the installation and liable to introduce a potential, generally the earth potential.

NOTE Examples are: Structural metal work of a building, water pipe and heating tubes etc. and non-electrical apparatus (radiators, gas or coal-fixed cooking ranges, metal sinks etc).

(F)

Facility
Physical entity (for example, a hospital, factory, machinery, etc.) that is built, constructed, installed or established to perform some particular function or to serve or facilitate some particular end.

Fairground
An area where one or more stands, amusement devices or booths are erected for leisure use.

Fastener
An attachment device used to secure the conductor to the structure.

Fault
Contact of a live part with exposed or extraneous conductive parts caused by accident or failure of insulation.

Fault current
A current resulting from an insulation failure or the bridging of insulation.

Fault protection
Protection against electric shock under single-fault conditions. For low-voltage installations, systems and equipment, fault protection generally corresponds to protection against indirect contact, mainly with regard to failure of basic insulation.

Final circuit (branch circuit)
A circuit connected directly to current using equipment or to socket-outlets.

Fixed equipment
Equipment fastened to a support or otherwise secured in a specific location.

Fixed wiring or cable
Wiring or cable mounted on a fixed support so that its position does not change.

Flame protection
Self-closing gauge hatches, vapour seals, pressure-vacuum breather valves, flame arresters, or other reasonably effective means to minimize the possibility of flame entering the vapour space of a tank.

Flammable air-vapour mixtures
Flammable vapours mixed with air in proportions that will cause the mixture to burn rapidly when ignited. The combustion range for ordinary petroleum products, such as gasoline, is from about $1^1/_2$ to $7^1/_2$ percent of vapour by volume, the remainder being air.

Flammable element
Any element capable of being easily ignited.

Flammable Vapours
The vapours given off from a flammable or combustible liquid at or above its flash point.

Flameproof enclosure “d” (of hazardous location)
Type of protection, in which, the parts which can ignite an explosive atmosphere are placed in an enclosure which can withstand the pressure developed during an internal explosion of an explosive mixture and which prevents the transmission of the explosion to the explosive atmosphere surrounding the enclosure.

Flasher
Device for automatically switching one or more output circuits on and off continuously. The sequence of switching of the various output circuits may be suitably arranged to provide the impression of movement and other animated effects.

Flash duration
Time for which the lightning current flows at the point of strike.

Flash point
The minimum temperature at which a liquid gives off vapour in sufficient concentration to form an ignitable mixture with air that is near the surface of the liquid within the vessel, as specified by appropriate test procedure and apparatus.

Flexible cable
A cable whose structure and materials make it suitable to be flexible while in service.

Flexible cord
A flexible cord in which the cross-sectional area of each conductor dose not exceed 4 mm^2.

Flexible wiring system
A wiring system designed to provide mechanical flexibility in use without degradation of the electrical components.

Functional earthing
Connection to earth necessary for proper functioning of electrical equipment.

Functional extra low-voltage (FELV)
An extra low-voltage system in which not all of the protective measures required for SELV or PELV have been applied.

Functional switching
An operation intended to switch “on” or “off” or vary the supply of electrical energy to all or part of an installation for normal operating purposes.

Fuse
A device designed to break a circuit on the occurrence of an overcurrent, by means of the thermal melting of itself or of its components.

(G)

Galvanic isolation
Arrangement within an item of intrinsically safe apparatus such that a signal is transferred from the apparatus input to the apparatus output without any direct electrical connection between the two.

NOTE Galvanic isolation frequently utilizes either magnetic (transformer or relay) or opto-coupled elements.

Gastight
Structures so constructed that gas or air cannot enter or leave the structure except through vents or piping provided for the purpose.

General lighting
All lighting, other than the emergency lighting, permanently installed in parts of the premises to which persons have access.

Guide rails (of a lift)
Rigid vertical guides whose inclination to the vertical is not more than 15^o, providing guide for the car or the counterweight, if there is one.

(H)

Hand-held equipment
Portable equipment intended to be held in the hand during normal use, in which the motor, if any, forms an integral part of the equipment.

Hazardous area (location)
Area (location) in which an explosive gas atmosphere is present, or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of apparatus.

Hazardous-live-part
Live part, which under certain conditions, can give a harmful electric shock. In case of high voltage, a hazardous voltage may be present on the surface of solid insulation. In such a case, the surface is considered a hazardous-live-part.

High leakage current
Earth leakage current exceeding the limit specified in and measured in accordance with SASO … for equipment connected via a plug and socket complying with SASO … or similar.

High-rise building
A structure exceeding 23 m in height.

(I)

Impulse charge ($Q_{impulse}$)
The time integral of the lightning current for the impulse part of the lightning flash duration.

Increased safety “e” (of hazardous location)
Type of protection applied to electrical apparatus in which additional measures are applied so as to give increased security against the possibility of excessive temperatures and of the occurrence of arcs and sparks in normal service or under specified abnormal conditions.

Indirect contact
Dangerous contact of persons, livestock, or objects with exposed conductive parts or extraneous conductive parts, which have become live because of a fault.

Initial starting current I_A
Highest r.m.s. value of current absorbed by an a.c. motor at rest when supplied at the rated voltage and frequency.

Input circuit
That part of the device or installation between the point at which electrical energy is supplied to an installation and the input terminals of the transformer, converter or inverter.

NOTE Also known as a 'mains supply circuit'.

Inspection
Inspection is performed by samples. It may be unexpected and may occur during the electrical work or at the end of the work.

Inspection Body
A Electrical Requirements accredited body approved to make the verification as per the Electrical Requirements and entitled to endorse a test report.

Installer
Person, qualified in sign installation practice, who takes responsibility for the installation and its testing in accordance with this standard.

Insulation
Non-conducting material enclosing surrounding, or supporting a live part.

Insulating sleeve
Insulation designed to be placed over the exposed high-voltage connections at tube electrodes or over cable-end insulators.

Intermediate part
An inaccessible conductive part, which is not live in normal operation.

Intrinsically safe circuit (of hazardous location)
Circuit in which all the apparatus is either intrinsically safe apparatus or simple apparatus.

Intrinsically safe electrical system
Assembly of interconnected items of electrical apparatus, described in a descriptive system document, in which the circuits or parts of circuits intended to be used in an explosive atmosphere are intrinsically safe.

Intrinsically safe sub-circuit
Part of an intrinsically safe circuit, which is galvanically isolated from another part or other parts of the same intrinsically safe circuit.

Intrinsically safe equipment (apparatus)
Electrical equipment apparatus in which all the circuits are intrinsically safe.

Intrinsic safety “i”
Type of protection based upon the restriction of electrical energy within apparatus and of interconnecting wiring exposed to an explosive atmosphere to a level below that which can cause ignition by either sparking or heating effects.

NOTE Because of the method by which intrinsic safety is achieved, it is necessary to ensure that not only the electrical apparatus exposed to the explosive atmosphere but also other electrical apparatus with which it is interconnected is suitably constructed.

Inverter
Transducer that converts direct current to alternating current.

Isolated Extra-Low-voltage (IELV)
A voltage not exceeding 50 V a.c. at any point of a circuit, which is separated from circuits with higher voltages by insulation at least equivalent to that for Class II or which has equivalent protective means.

Isolating transformer
A transformer, the input winding of which is electrically separated from the output winding by insulation at least equivalent to double insulation or reinforced insulation.

Isolation
A function intended to cut off for reasons of safety the supply from all or a discrete section of the installation by separating the installation or section from every source of electrical energy.

Isolation and switching
Effective means, suitably placed for ready operation, shall be provided so that all voltage may be cut off from every installation, from every circuit thereof and from all equipment, as may be necessary to prevent or remove danger.

(L)

Labelled
Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labelled equipment or materials, and by whose labelling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

Leakage current
A current which, in the absence of a fault, flows to earth or to extraneous conductive parts in a circuit.

Leisure accommodation vehicle
Unit of living accommodation for temporary or seasonal occupation that may meet requirements for construction and use of road vehicles.

Leisure home
Transportable leisure accommodation vehicle, usually for holiday use, that does not meet requirements for construction and use of road vehicles.

Lift
Equipment serving defined landing levels, consisting of a car, running between guide rails.

Lift car
A part of the lift, which carries the passengers and/or goods.

Lift machine
The unit, including the motor, which drives and stops the lift car.

Lift well
The space in which the car and the counterweight, if there is one, travel, the space is bounded by the bottom of the bit, the walls and the roof of the well.

Lightning current
The current flowing at the point of strike.

Lightning electromagnetic pulse
Voltages or currents induced into cables and other conductors by the radiated field from a lightning flash some distance away. (LEMP may have nuisance value to electronic systems but rarely gives transients of high voltage or high energy).

Lightning flash to earth
Electrical discharge of atmospheric origin between cloud and earth consisting of one or more strokes.

Lightning strike
A lightning flash attaching to a structure.

Lightning stroke
One of the single distinguishable current impulses of a lightning flash.

Lightning protection system (LPS)
Complete system used to protect a space against the effects of lightning. It consists of both external and internal lightning protection systems. In particular cases, an LPS may consist of an external LPS or an internal LPS only.

Live part
A conductor or conductive part intended to be energized in normal use, including a neutral conductor, but, by convention, not a PEN conductor.

Load factor (utilization factor)
The ratio expressed as a numerical value or as a percentage, of the consumption within a specified period (year, month, day, etc.), to the consumption that would result from continuous use of the maximum or other specified demand occurring within the same period.

Loop conductor
A conductor encircling a structure that is used to interconnect earth terminals, main conductors, or other earthed bodies.

Low noise earth
An earth connection in which the level of conducted interference from external sources does not produce an unacceptable incidence of malfunction in the data processing or similar equipment to which it is connected.

Low-voltage
A nominal voltage exceeding 50 V a.c. or 75 V d.c., but not exceeding 1000 V a.c. or 1500 V d.c.

Luminaire
An apparatus which distributes, filters or transforms the light transmitted from one or more lamps and which includes all the parts necessary for supporting, fixing and protecting the lamps, but not the lamps themselves, and where necessary circuit auxiliaries together with the means for connecting them to the supply.

Luminous-discharge tube
Tube, or other vessel or device, which is constructed of translucent material, hermetically sealed, and designed for the emission of light arising from the passage of an electric current through a gas or vapour contained within it. The tube may be with or without a fluorescent coating.

(M)

Machine room (of a lift)
A room in which the lift machine(s) and associated equipment are placed.

Main conductor (of lightning protection)
A conductor intended to be used to carry lightning currents between strike termination devices and earth terminals. For catenary systems, the overhead earth wire is both a strike termination device and a main conductor.

Main distribution board
Board in the building, which fulfils all the functions of a main electrical distribution for the supply building area assigned to it and where the voltage drop is measured for operating the safety services.

Main earthing terminal (main earthing or grounding busbar)
A terminal or busbar provided for the connection of protective conductors, including equipotential bonding conductors and conductors for functional earthing if any, to the means of earthing.

Maintained mode
Operating mode of electrical equipment, essential for safety services, operating at all times.

Marina
Any fixed wharf, jetty, pier or floating pontoon arrangements capable of berthing or mooring more than one pleasure craft.

Maximum external capacitance (C_o)
Maximum capacitance in an intrinsically safe circuit that can be connected to the connection facilities of the apparatus without invalidating intrinsic safety.

Maximum external inductance (L_o)
Maximum value of inductance in an intrinsically safe circuit that can be connected to the connection facilities of the apparatus without invalidating intrinsic safety.

Maximum external inductance to resistance ratio (L_o/R_o)
Ratio of inductance (L_o) to resistance (R_o) of any external circuit connected to the connection facilities of the electrical apparatus without invalidating intrinsic safety.

Maximum input current (I_i)
Maximum current (peak a.c. or d.c.) that can be applied to the connection facilities for intrinsically safe circuits without invalidating intrinsic safety.

Maximum input power (P_i)
Maximum input power in an intrinsically safe circuit that can be dissipated within an apparatus when it is connected to an external source without invalidating intrinsic safety.

Maximum input voltage (U_i)
Maximum voltage (peak a.c. or d.c.) that can be applied to the connection facilities for intrinsically safe circuits without invalidating intrinsic safety.

Maximum internal capacitance (C_i)
Total equivalent internal capacitance of the apparatus which is considered as appearing across the connection facilities of the apparatus.

Maximum internal inductance (L_i)
Total equivalent internal inductance of the apparatus which is considered as appearing at the connection facilities of the apparatus.

Maximum internal inductance to resistance ratio (L_i/R_i)
Ratio of inductance (L_i) to resistance (R_i) which is considered as appearing at the external connection facilities of the electrical apparatus.

Maximum output current (I_o)
Maximum current (peak a.c. or d.c.) in an intrinsically safe circuit that can be taken from the connection facilities of the apparatus.

Maximum output power (P_o)
Maximum electrical power in an intrinsically safe circuit that can be taken from the apparatus.

Maximum output voltage (U_o)
Maximum output voltage (peak a.c. or d.c.) in an intrinsically safe circuit that can appear under open-circuit conditions at the connection facilities of the apparatus at any applied voltage up to the maximum voltage, including U_m and U_i.

Maximum (r.m.s. a.c. or d.c.) voltage (U_m)
Maximum voltage that can be applied to the non-intrinsically safe connection facilities of associated apparatus without invalidating intrinsic safety.

Maximum surface temperature
Highest temperature, which is attained in service under the most adverse operating conditions (but within recognized tolerances) by any part or surface of the electrical

apparatus, which would be able to produce an ignition of the surrounding explosive atmosphere.

NOTE 1 The most adverse conditions include recognized overloads and fault conditions recognized in the specific standard for the type of protection concerned.

NOTE 2 The relevant surface temperature may be internal and/or external depending upon the type of protection concerned.

Medical electrical equipment
Electrical equipment provided with not more than one connection to a particular supply mains and intended to diagnose, treat or monitor the patient under medical supervision and which

- makes physical or electrical contact with the patient, and/or
- transfers energy to or from the patient, and/or
- detects such energy transfer to or from the patient.

Medical electrical system
Combination of items of equipment, at least one of which is an item of medical electrical equipment and inter-connected by functional connection or use of a multiple portable socket-outlet.

Medical information technology system
Electrical system having specific requirements for medical applications.

Medical location
Location intended for purposes of diagnosis, treatment (including cosmetic treatment), monitoring and care of patients.

Metal-clad structure
A structure with sides or roof, or both, covered with metal.

Metal-framed structure
A structure with electrically continuous structural members of sufficient size to provide an electrical path equivalent to that of the lightning conductors covered in this standard.

Mobile home
Leisure home that retains means for mobility.

Motor caravan
Self-propelled leisure accommodation vehicle, used for touring that meets requirements for construction and use of road vehicles. It is either adapted from a series production vehicle, or designed and built on an existing chassis, with or without the driving cab, the accommodation being either fixed or dismountable.

Mutual inductance
The property of a circuit whereby a voltage is induced in a loop by a changing current in a separate conductor.

(N)

Near flash
Flash striking in the vicinity of the structure of interest.

Neutral conductor (symbol N)
A conductor connected to the neutral point of a system and capable of contributing to the transmission of electrical energy. In some cases, and under specified conditions, an earthed neutral conductor may also serve as a protective conductor.

No-load rated output voltage
Maximum rated voltage between the terminals of the output winding(s) of the transformer, inverter or converter connected to the rated supply voltage at rated frequency, with no load on the output circuit. For output circuits supplied by transformers, it is the peak value divided by the square root of 2. For output circuits supplied by inverters or converters, it is the r.m.s. value or the peak value divided by 2, whichever is the greater.

Nominal voltage
Voltage by which an installation or part of an installation is designated. The actual voltage may differ from the nominal voltage within permitted tolerances.

Non-conducting environment
Provision whereby a person or an animal touching an exposed-conductive-part that has become hazardous-live is protected by the high impedance of his environment (e.g. insulating walls and floors) and by the absence of earthed conductive parts.

Non-hazardous area
Area in which an explosive gas atmosphere is not expected to be present in quantities such as to require special precautions for the construction, installation and use of apparatus.

Non-maintained mode
Operating mode of electrical equipment, essential for safety services, operating only when the normal supply fails.

Normal operation
Operation of apparatus conforming electrically and mechanically to its design specification and is used within the limits specified by the manufacturer.

NOTE The limits specified by the manufacturer may include persistent operational conditions such as stalled rotors, failed lamps and overloads.

Normal supply
An electricity supply taken from the Supply Authority or alternatively from the proprietor's own generating plant.

(O)

Obstacle
A part preventing unintentional direct contact, but not preventing direct contact by deliberate action.

Open-circuit protective device
Device, which will remove the output power from one or more transformer(s), inverter(s) or converter(s) in the event of an interruption of the secondary high voltage circuit.

Origin of an electrical installation (service entrance)
The point at which electrical energy is delivered to. An electrical installation may have more than one origin.

Origin of the external lighting installation
The origin of the external lighting installation is the supply delivery point of electrical energy by the supply authority or the origin of the circuit supplying the external lighting installation exclusively.

Origin of the temporary electrical installation
Point on the permanent installation or other source of supply from which electrical energy is delivered.

Outdoors
Location where all or part of an equipment, a sign or luminous-discharge-tube installation or its components are situated out of doors and are subject to the effects of weather.

Output circuit (of electric signs)
That part of the device or installation between the output terminals of the transformer, converter or inverter and the discharge tubes inclusive.

NOTE Also known as a 'lamp circuit'.

Overcurrent
Any current exceeding the rated value, for conductors, the rated value is the current-carrying capacity.

Overcurrent detection
A function establishing that the value of current in a circuit exceeds a predeterminated value for a specified length of time.

Overload current
An overcurrent occurring in a circuit in the absence of an electrical fault.

Overvoltage
Any voltage exceeding the nominal voltage of the installation.

(P)

Patient environment
Any volume in which intentional or unintentional contact can occur between patient and parts of the system or between patient and other persons touching parts of the system.

PEL conductor
Conductor combining the functions of both a protective earthing conductor and a line conductor, the acrongm PEL results of the combination of both symbols PE for the protective conductor and L for the line conductor.

PEN conductor
An earthed conductor combining the functions of both protective conductor and neutral conductor, the acronym PEN results of the combination of both symbols PE for the protective conductor and N for the neutral conductor.

PEM conductor
Conductor combining the functions of both a protective earthing conductor and a mid-point conductor, the acronym PEM results of the combination of both symbols PE for the protective conductor and M for the mid-point conductor.

Periodic test
A test(s), which is intended for reporting on the condition of an existing electrical installations every interval specified period. In addition, it includes the examination of the effects of any change in use of the premises from that for which the installations were previously provided.

Phase conductor
A conductor of an ac system for the transmission of electrical energy other than a neutral conductor, a protective conductor or a PEN conductor, the term means the equivalent conductor of a dc system unless otherwise specified in these Electrical Requirements.

Pleasure craft
Any boat, vessel, yacht, motor launch, houseboat or other floating craft used exclusively for sport or leisure.

Pitched roofs
It is defined as roofs having a span of 12 m or less and a pitch $^{1}/_{8}$ or greater; and roofs having a span of more than 12 m and a pitch $^{1}/_{4}$ or greater. All other roofs shall be considered flat or gently sloping.

Plug
A device, provided with contact pins which is intended to be attached to a flexible cable, and which can be engaged with a socket-outlet or with a connector.

Pressure piling
Condition resulting from the ignition of pre-compressed gases in compartments or subdivisions other than those in which ignition was initiated.

NOTE This may lead to a higher maximum pressure than would otherwise be expected.

Point of strike
Point where a lightning stroke contacts the earth, a structure, or an LPS.

Portable equipment
Equipment which is moved while in operation or which can easily be moved from one place to another while connected to the supply.

Potential grading
Control of the earth potential, especially the earth surface potential, by means of earth electrodes.

Power factor
The ratio between of the active power (kW) and the apparent power (kVA).

Power factor improvement
The addition of reactive components (typically capacitive) to establish a system power factor closer to unity.

Precaution in adverse conditions
All equipment likely to be exposed to weather, corrosive atmospheres or other adverse conditions shall be constructed or protected as may be necessary to prevent danger arising from such exposure.

Pressurization "p" (of hazardous location)
Technique of guarding against the ingress of the external atmosphere into an enclosure by maintaining a protective gas therein at a pressure above that of the external atmosphere.

Primary maintained lighting
The lighting, which is switched on while persons are on the premises.

Prospective overvoltage
Theoretical overvoltage that would appear on the conductors of a power supply system or user installation before flashover of basic insulation or operation of voltage-limiting devices.

Prospective touch voltage
The highest touch voltage liable to appear in the event of a fault of negligible impedance in the electrical installation.

Protective bonding terminal
Terminal intended for protective-equipotential-bonding purpose.

Protective equipotential bonding
Equipotential bonding for purposes of safety (e.g. protection against electric shock).

Protective extra low-voltage (PELV)
An extra low-voltage system which is not electrically separated from earth but which otherwise satisfies all the requirements for SELV.

Protective impedance device
Component or assembly of components the impedance and construction of which are such as to ensure that steady-state touch current and charge are limited to non-hazardous levels.

PV (Photovoltaic) cell
Basic PV device, which can generate electricity when exposed to light such as solar radiation.

PV (ac side)
Part of a PV installation from the AC terminals of the PV inverter to the point of connection of the PV supply cable to the electrical installation.

PV main cable (a.c.)
Cable connecting the PV generator junction box to the DC terminals of the PV inverter.

PV module (a.c.)
Integrated module/inverter assembly where the electrical interface terminals are AC only. No access is provided to the DC side.

PV (dc side)
Part of a PV installation from a PV cell to the DC terminals of the PV inverter.

PV array
Mechanically and electrically integrated assembly of PV modules, and other necessary components, to form a DC power supply unit.

PV array cable
Output cable of a PV array.

PV array junction box
Enclosure where all PV strings of any PV array are electrically connected and where protection devices can be located if necessary.

PV generator
Assembly of PV arrays.

PV generator junction box
Enclosure where all PV arrays are electrically connected and where protection devices can be located if necessary.

PV installation
Erected equipment of a PV power supply system.

PV inverter
Device, which converts DC voltage and DC current into AC voltage and AC current.

PV module
Smallest completely environmentally protected assembly of interconnected PV cells.

PV open-circuit voltage under standard test conditions $U_{OC\ STC}$
Voltage under standard test conditions across an unloaded (open) PV module, PV string, PV array, PV generator or on the DC side of the PV inverter.

PV short-circuit current under standard test conditions $I_{SC\ STC}$
Short-circuit current of a PV module, PV string, PV array or PV generator under standard test conditions.

PV string
Circuit in which PV modules are connected in series, in order for a PV array to generate the required output voltage.

PV string cable
Cable connecting PV modules to form a PV string.

PV supply cable
Cable connecting the AC terminals of the PV inverter to a distribution circuit of the electrical installation.

(R)

Rated current of a circuit
The maximum value of current for which the circuit is intended.

Rated current of a protective device
The value of current from which the operating conditions of the protective device are determined. For adjustable protective devices, the current setting is considered as the rated current.

Rated operating differential current
Differential current specified by the manufacturer for a protection device, at which that device shall operate under conditions prescribed in the relevant specifications.

Rated voltage
The rated voltage indicates the upper limit of the highest voltage of the system for which the switchgear and controlgear is intended.

Reactive power
The power associated with reactive elements that provides a measure of the energy associated with setting up the magnetic and electric fields of inductive and capacitive elements respectively.

Reference earth
Part of the earth considered as conductive, the electric potential of which, is conventionally taken as zero, being outside the zone of influence of any earthing arrangement.

Reinforced insulation
Improved basic safety insulation, which provides the same degree of protection against electric shock as double insulation.

Residual current
The algebraic sum of the instantaneous values of current flowing through all live conductors of circuit at a point of the electrical installation.

Residual current device (RCD)
A mechanical switching device or association of devices intended to cause the opening of the contacts when the residual current attains a given value under specified conditions.

Residual operating current
Residual current, which causes the residual current device to operate under specified conditions.

Resistance area for an earth electrode
The surface area of earth (around an earth electrode) on which a significant voltage gradient may exist.

Restrictive conductor location
A location comprised mainly of metallic or conductive surrounding parts, within which it is likely that a person will come into contact through a substantial portion of their

body with the conductive surrounding parts and where the possibility of preventing this contact is limited.

Ring conductor
A conductor forming a loop around the structure and interconnecting the down conductors for an equal distribution of lightning current among them.

Ring earth electrode
An earth electrode forming a close loop round the structure below or on the surface of the earth, or within or under the foundations.

Ring final circuit
A final circuit arranged in the form of a ring and connected to a single point of supply.

Ripple-free (d.c.)
It is conventionally defined for sinusoidal ripple voltage as a ripple content of not more than 10%, the maximum peak value does not exceed 140 V for a nominal 120 V ripple-free d.c. system and 70 V for a nominal 60 V ripple-free d.c. system.

Rising mains
Conductors for internal unmetered supply.

(S)

Safety (Separated) Extra-Low-Voltage (SELV) system
Extra-Low-Voltage system (i.e. normally not exceeding 50 V a.c. or 120 V ripple-free d.c.) which is electrically separated from earth and from other systems in such a way that a single fault cannot give rise to an electric shock.

NOTE A 50 V earth free system is a SELV system.

Safety services equipment
Equipment, the operation of which under emergency conditions, including possible failure of the normal supply, is specified for reasons of safety of persons.

Safety transformer
A transformer the input winding of which is electrically separated from the output winding by insulation at least equivalent to double insulation or reinforced insulation, and which is designed to supply isolated extra-low-voltage circuits.

Sealing ring
Ring used in a cable or conduit entry to ensure sealing between the entry and the cable or conduit.

Secondary maintained lighting (emergency or safety lighting)
A lighting system energized from an alternative source of supply (e.g. a battery) in which designated areas are illuminated at all times when the premises are occupied.

Secondary non-maintained lighting
A lighting system energized from an alternative source of supply (e.g. a battery) in which designated areas are illuminated automatically upon the failure of the normal supply.

Self-contained battery unit
Unit comprising a battery and a charging and testing unit.

Self inductance
The property of a wire or a circuit witch causes a back electromagnetic field (EMF) to be generated when a changing current flows through it.

Separated (Safety) Extra-Low-Voltage (SELV)
An Extra-Low-Voltage system, which electrically separated from earth and from other systems in such a way that a single fault cannot give rise to the risk of electric shock.

Simple apparatus (of hazardous location)
Electrical component or combination of components of simple construction with well-defined electrical parameters, which is compatible with the intrinsic safety of the circuit in which it is used.

NOTE The following apparatus is considered to be simple apparatus:
a) passive components, e.g. switches, junction boxes, resistors and simple semi-conductor devices;
b) sources of stored energy with well-defined parameters, e.g. capacitors or inductors, whose values are considered when determining the overall safety of the system;
c) sources of generated energy, e.g. thermocouples and photocells, which do not generate more than 1.5 V, 100 mA and 25 mW. Any inductance or capacitance present in these sources of energy are considered as in b) above.

Shock current
A current passing through a body of a person or animal and having characteristics likely to cause pathophysiological effects.

Short-circuit current
An overcurrent resulting from a fault of negligible impedance between live conductors having a difference in potential under normal operating conditions.

Show
Display or performance in any suitable location, either a room, building or temporary structure.

Side flash
An electrical spark caused by differences of potential that occurs between conductive metal bodies or between such metal bodies and a component of the lightning protection system or earth.

Simple separation
Separation between circuits or between a circuit and earth by means of basic insulation.

Simultaneously accessible parts
Conductors or conductive parts which can be touched simultaneously by a person, or, where applicable, by livestock.

Skilled person
A person with technical knowledge or sufficient experience to enable him to avoid dangers which electricity may create.

Small portable sign
Small sign which can easily be moved from one place to another; which is supplied with an integral transformer, inverter or converter, together with a flexible mains supply lead and plug; and which is intended to be installed and connected by the customer to a socket-outlet of the mains supply.

Socket-outlet
A device, provided with female contacts, which is intended to be installed with the fixed wiring, and intended to receive a plug. A luminaire track system is not regarded as a socket-outlet system.

Spark gap
Any short air space between two conductors that are electrically insulated from or remotely electrically connected to each other.

SPD disconnector
Internal or external device required for disconnecting a surge protective device (SPD) from the system in the event of SPD failure. It is intended to prevent a persistent fault on the system and may give visible indication of the SPD failure.

Stack, heavy-duty (of lightning protection)
A smoke or vent stack with the cross-sectional area of the flue greater than 0.3 m^2 and the height greater than 23 m.

Stand
Area or temporary structure used for display, marketing, sales, entertainment.

Standby supply system
A supply system intended to maintain the functioning of the installation or part of the installation in case of interruption of the normal supply, for reasons other than safety of persons.

Starting current ratio I_A/I_N
Ratio between initial starting current I_A and rated current I_N.

Stationary equipment
Either fixed equipment or equipment not provided with a carrying handle and having such a mass that it cannot be moved easily.

Steel bonding bar
Common steel rod tied to the reinforcing bars with steel wires of reinforced concrete structure to which bonding conductors or other interconnecting conductors are welded or clamped.

Steel bonding connector
Connection used for the steel rods which are lashed to the reinforcing rods and which are employed for connection of the equipotential bonding inside the building to the reinforcing rods and thus distributes the introduce current among the reinforcing rods.

Steepness factor (of impulse wave)
Ratio for a current impulse, of the front-of wave slope defined for the interval between 10 % and 90 % of the crest value, to the slope defined for the interval between 10 % and 30 % of the crest value.

Step voltage
Voltage between two points on the earth's surface that are 1 m distant from each other, which is considered to be the stride length of a person.

Strike termination device
A component of a lightning protection system that is intended to intercept lightning flashes and connect them to a path to earth. Strike termination devices include air terminals, metal masts, meshed cages, permanent metal parts of structures and overhead earth wires installed in catenaries lightning protection systems.

Striking distance
The distance over which the final breakdown of the initial stroke occurs.

Stroke (lightning)
Single electrical discharge in a lightning flash to earth.

Supplementary insulation
Independent insulation provided in addition to the basic safety insulation in order to ensure protection against electric shock in the event of failure of the basic safety insulation.

Supply system
Supply system is intended to include the source and the circuits up to the terminals of the equipment using current. In certain cases it may also include the current using equipment.

Supply system for safety services (emergency power system)
A supply system intended to maintain the functioning of equipment essential for the safety of persons. Safety services are often a statutory requirement in premises open to the public, in very high building and in certain industrial premises.

Surge arrester
A protective device used for limiting surge voltages by discharging or bypassing surge current. A surge arrester can also prevent continued flow of follow current while remaining capable of discharging or bypassing surge current.

Surge overvoltage
temporary or transient voltage occurring in the system, resulting from a surge current due to an atmospheric discharge, an induction phenomenon, switching, or a fault in the system itself.

Surge protective device (SPD)
Device that is intended to limit transient overvoltages and divert surge currents. It contains at least one non-linear component.

Surge reference equalizer
device used for connecting equipment to external systems whereby all conductors connected to the protected load are routed, physically and electrically, through a single

enclosure with a shared reference point between the input and output ports of each system.

Surface resistivity
Average resistivity of the surface layers of the soil.

Switch
A manually operated mechanical device normally used for disconnecting an installation, or part of an installation, from the supply.

Switchboard
An assembly of switchgear with or without instruments, but the term does not apply to groups of local switches in final circuits.

Switchgear and controlgear
Equipment provided to be connected to an electrical circuit for carrying out one or more of the following functions; protection, control, isolation, switching.

Switching off for mechanical maintenance
An operation intended to inactivate an item or items of electrically powered equipment for preventing danger, other than due to electric shock or to arcing, during non-electrical work on this equipment.

(T)

Temporary electrical installation
Electrical installation erected and dismantled at the same time as the stand or display with which it is associated.

Temporary overvoltage
Oscillatory overvoltage at power frequency at a given location, of relatively long duration and which is undamped or weakly damped. Temporary overvoltages usually originate from switching operations or faults (for example, sudden load rejection, single-phase faults) and/or from non-linearities (ferro-resonance effects, harmonics).

Temporary structure
A unit or a part of a unit including mobile portable units, situated indoors or outdoors, designed and intended to be assembled and dismantled.

Test(s)
The required test(s) specified in PART SIX, which verify the confirmation of the Saudi Building Code requirements.

Thermal runaway
Operational condition when the sustained power loss of an SPD exceeds the thermal dissipation of the housing and connections, leading to a cumulative increase in the temperature of the internal elements culminating in failure.

Time t_E
Time taken for an a.c. rotor or stator winding, when carrying the initial starting current I_A, to be heated up to the limiting temperature from the temperature reached in rated service at the maximum ambient temperature.

Transfer inductance
The property of a circuit whereby a voltage is induced in a loop by changing current in another circuit, some part of witch is included in the loop.

Transient control level
The maximum level of transients occurring in a protected system, achieved by design of protection or by use of surge suppressors.

Total charge (Q_{total})
The time integral of the lightning current for entire lightning flash duration.

Total earthing resistance
The resistance between the main earthing terminal and the earth.

Touch current
Electric current passing through a human body or through an animal body when it touches one or more accessible parts of an installation or of equipment.

Touch voltage
Voltage appearing during an insulation fault, between simultaneously accessible parts. By convention, this term is used only in connection with protection against indirect contacts. In certain cases, the value of the touch voltage may be appreciably influenced by the impedance of the person in contact with these parts.

Transformer
A static piece of apparatus with two or more windings which, by electromagnetic induction, transforms a system of alternating voltage and current into another system of voltage and current usually of different values and at the same frequency for the purpose of transmitting electrical power.

Type of protection (of hazardous location)
Specific measures applied to electrical apparatus to avoid ignition of a surrounding explosive atmosphere.

(U)

Undervoltage
Any voltage less than the nominal voltage of the installation.

(V)

Vapour openings
Openings through a tank shell or roof that are above the surface of the stored liquid, such openings might be provided for tank breathing, tank gauging, fire fighting, or other operating purposes.

Vertical earth electrode (for lightning protection)
Earth electrode installed in soil in a vertical position or with an inclination to the vertical.

(W)

Watercraft (of marines)
All forms of boats and vessels up to 272 metric tons used for pleasure or commercial purposes, but excluding seaplanes, hovercraft, vessels with a cargo of flammable liquids, and submersible vessels.

Wiring system
An assembly made up of a cable or cables or busbars and the parts, which secure and, if necessary, enclose the cable(s) or busbars.

(Z)

Zone of lightning protection
The space adjacent to a lightning protection system that is substantially immune to direct lightning flashes, in other words it is the volume within witch a lightning conductor gives protection against a direct lightning strike by directing the strike to itself.

PART THREE

ASSESSMENT OF GENERAL CHARACTERISTICS

CHAPTER 31
PURPOSES, SUPPLIES AND STRUCTURE

31-1 Maximum demand and diversity factor

31-1.1 For economic and reliable design of an installation within thermal and voltage drop limits, a determination of maximum demand is essential.

31-1.2 In determining the maximum demand of an installation, or part thereof, diversity may be taken into account.

31-2 Types of distribution system

The following characteristics of the distribution system are to be assessed:

- types of systems of live conductors;
- types of system earthing.

31-2.1 Types of system of live conductors

The following systems of live conductors are taken into account in these Electrical Requirements:

AC systems	DC systems
Single-phase 2-wire.	2-wire
Two-phase 3-wire (phase shift angle 120^o).	
Three-phase 3-wire (star and delta connection).	
Three-phase 4-wire with neutral conductor or PEN-conductor, which by definition is not a live conductor.	

NOTE 1 In case of single phase 2-wire-arrangment which is derived from a three-phase 4-wire-arrangment the two conductors are designated as line conductor and neutral conductor or line conductor and PEN conductor.

NOTE 2 In installations with all loads connected between phases, the installation of the neutral conductor may not be necessary.

31-2.2 Types of system earthing

The following types of system earthing are taken into account in these Electrical Requirements.

NOTE 1 Figures 31-1 to 31-5 show examples of commonly used three-phase systems. Figures 31-6 to 31-10 show examples of commonly used d.c. systems.

NOTE 2 The codes used have the following meanings:

First letter – Relationship of the power system to earth:

T = direct connection of one point to earth;

I = all live parts isolated from earth, or one point connected to earth through an impedance.

Second letter – Relationship of the exposed-conductive-parts of the installation to earth:

T = direct electrical connection of exposed-conductive-parts to earth, independently of the earthing of any point of the power system;

N = direct electrical connection of the exposed-conductive-parts to the earthed point of the power system (in a.c. systems, the earthed point of the power system is normally the neutral point or, if a neutral point is not available, a phase conductor).

Subsequent letter(s) (if any) – Arrangement of neutral and protective conductors:

S = protective function provided by a conductor separate from the neutral or from the earthed line (or in a.c. systems, earthed phase) conductor.

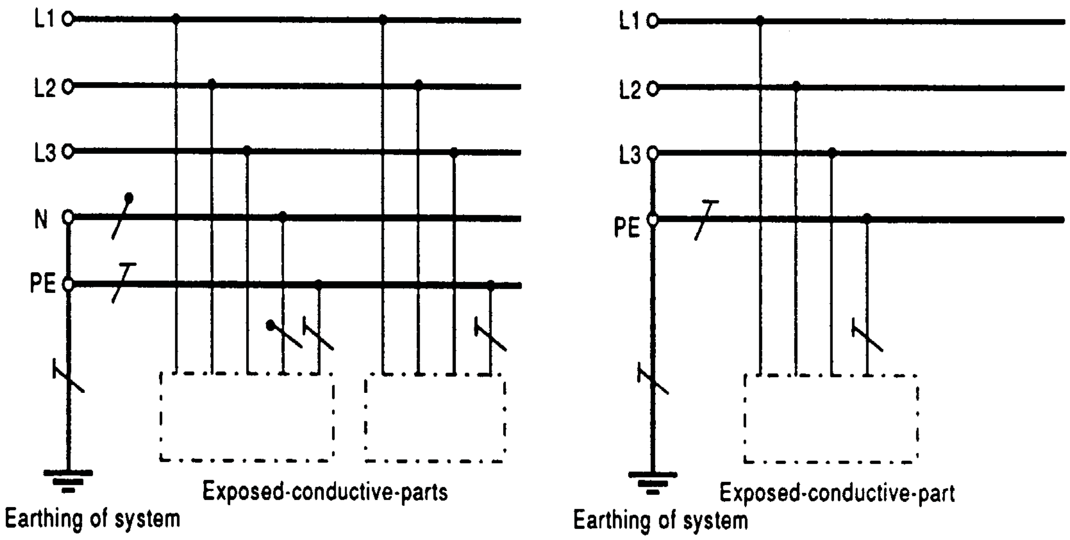
C = neutral and protective functions combined as a single conductor (PEN conductor).

31-2.2.1 TN systems

TN power systems have one point directly earthed, the exposed-conductive-parts of the installation being connected to that point by protective

conductors. Three types of TN system are considered according to the arrangement of neutral and protective conductors, as follows:

- TN-S system: in which throughout the system, a separate protective conductor is used;
- TN-C-S system: in which neutral and protective functions are combined in a single conductor in a part of the system;
- TN-C system: in which neutral and protective functions are combined in a single conductor throughout the system.



Separate neutral and protective conductors throughout the system

Separate earthed phase conductor and protective conductors throughout the system

NOTE For symbols, see explanation after figure 31-3.

Figure 31-1 TN-S system

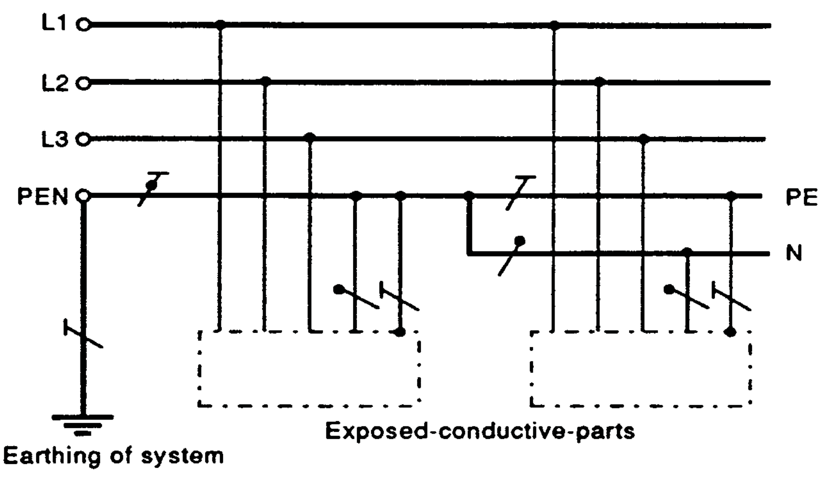


Figure 31-2 TN-C-S system – Neutral and protective functions combined in a single conductor in a part of the system

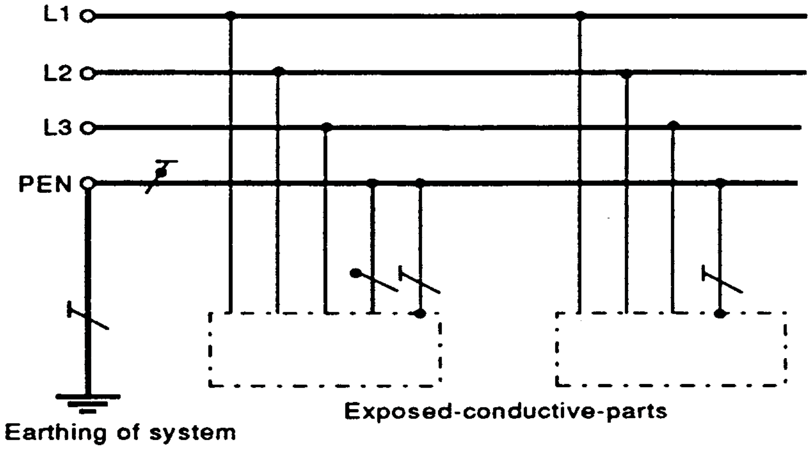
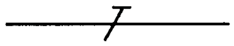


Figure 31-3 TN-C system – Neutral and protective functions combined in a single conductor throughout the system

Explanation of symbols for figures 31-1, 31-2, 31-3, 31-4 and 31-5 according to SASO IEC 60617-11	
	Neutral conductor (N)
	Protective conductor (PE)
	Combined protective and neutral conductor (PEN)

31-2.2.2 TT system

The TT power system has one point directly earthed, the exposed-conductive-parts of the installation being connected to earth electrodes electrically independent of the earth electrodes of the power system.

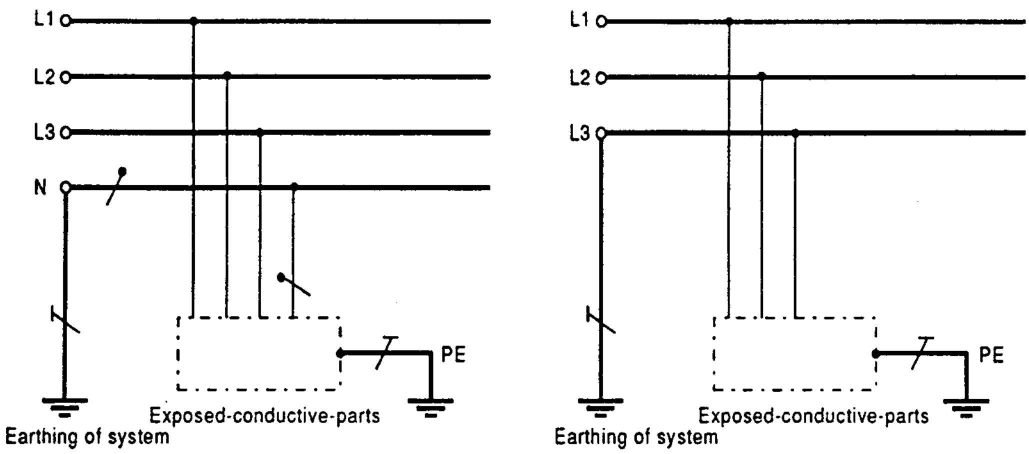
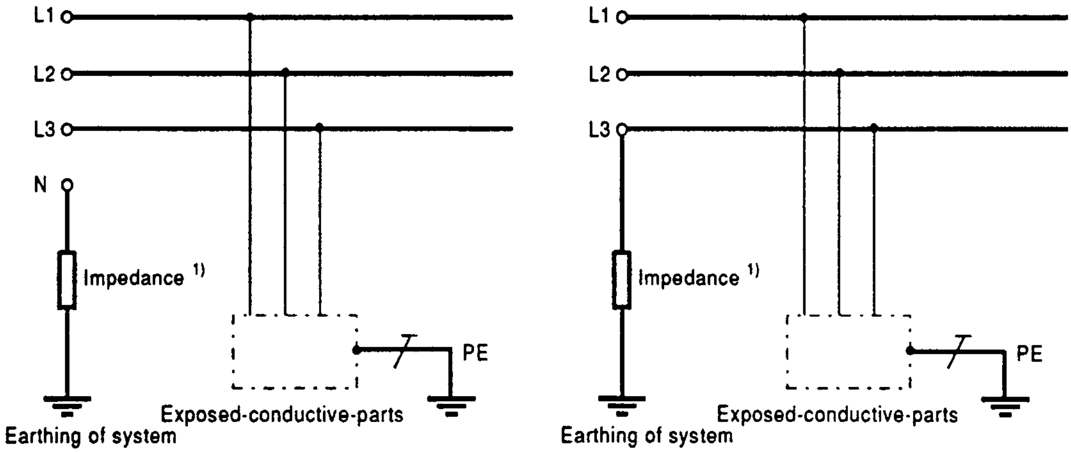


Figure 31-4 TT system

31-2.2.3 IT system

The IT power system has all live parts isolated from earth or one point connected to earth through an impedance, the exposed-conductive-parts of the electrical installation being earthed independently or collectively or to the earthing of the system (see 41-3.1.5 of Chapter 41).



1) The system may be isolated from earth. The neutral may or may not be distributed.

Figure 31-5 IT system

31-2.2.4 DC systems

Type of system earthing for direct current (d.c.) systems.

NOTE In earthed d.c. systems electromechanical corrosion should be considered.

Where the following figures 31-6 to 31-10 show earthing of a specific pole of a two-wire d.c. system, the decision whether to earth the positive or the negative pole shall be based upon operational circumstances or other considerations.

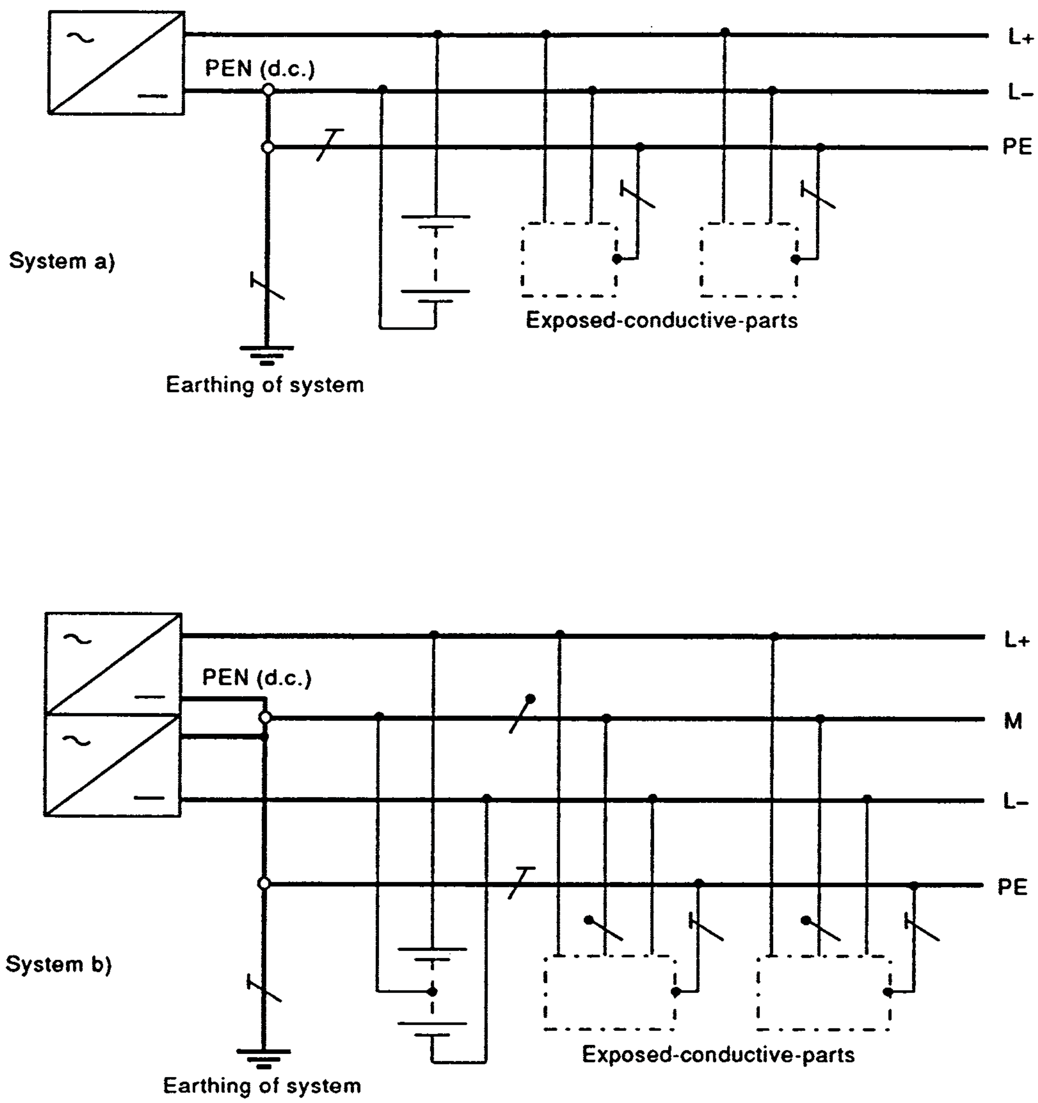
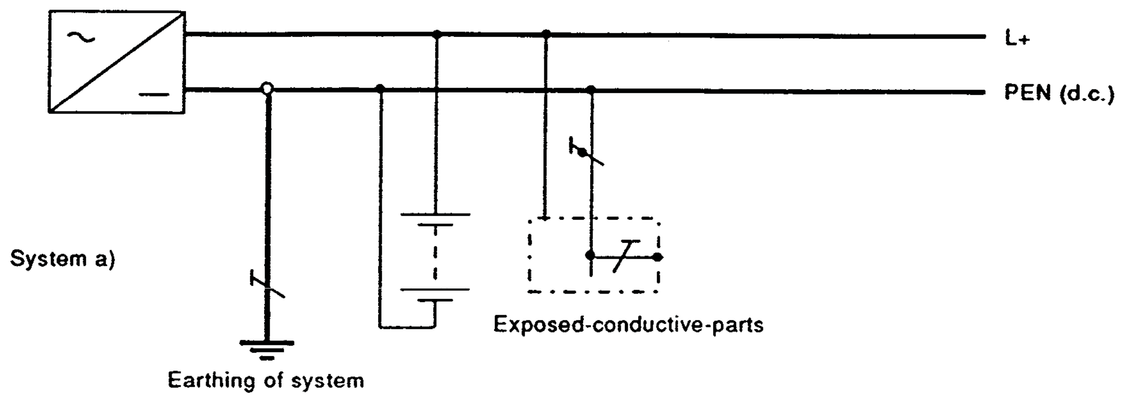


Figure 31-6 TN-S d.c. system

The earthed line conductor (for example L–) in system a) or the earthed mid-wire conductor, M, in system b) are separated from the protective conductor throughout the system.



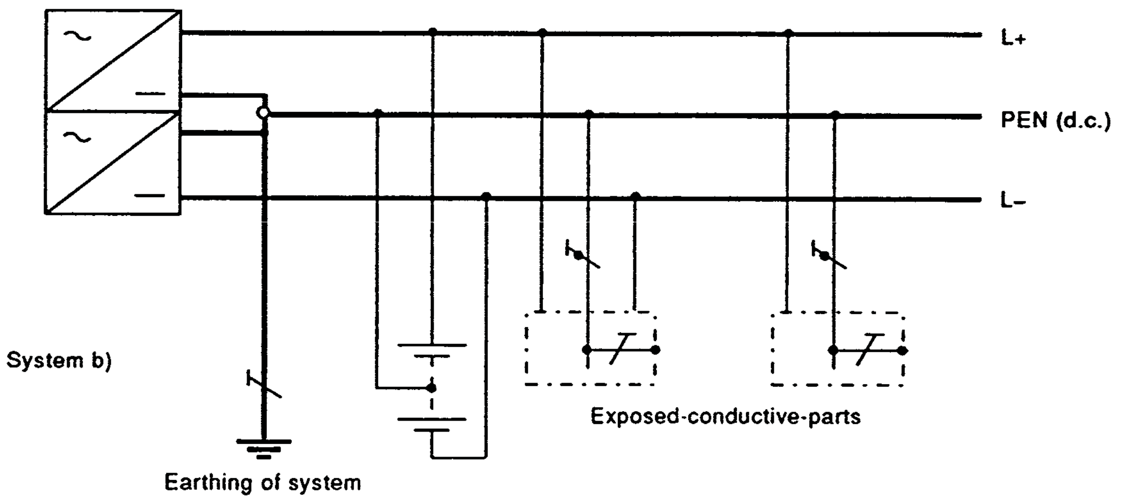
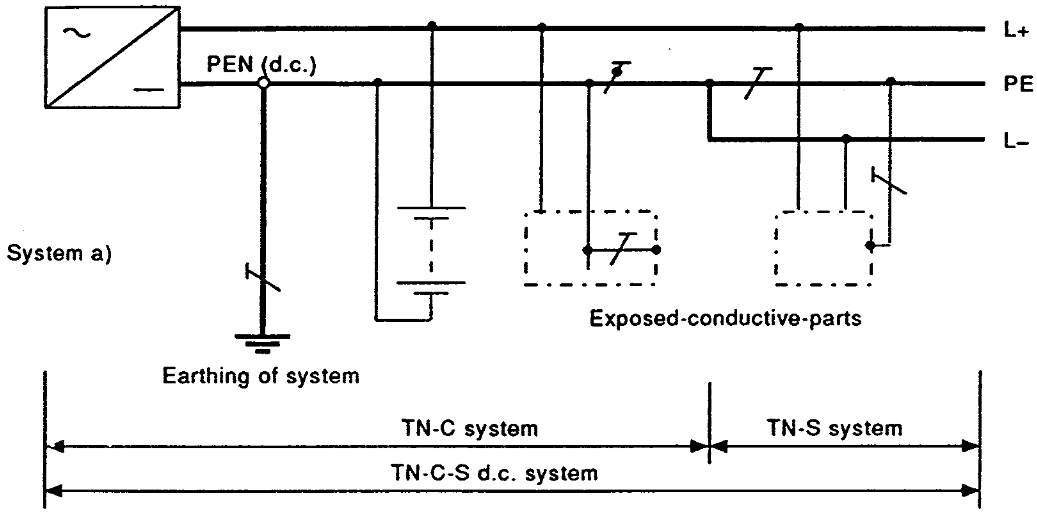


Figure 31-7 TN-C d.c. system

The functions of the earthed line conductor (for example L–) in system a) and protective conductor are combined in one single conductor PEN (d.c.) throughout the system, or the earthed mid-wire conductor, M, in system b) and protective conductor are combined in one single conductor PEN (d.c.) throughout the system.



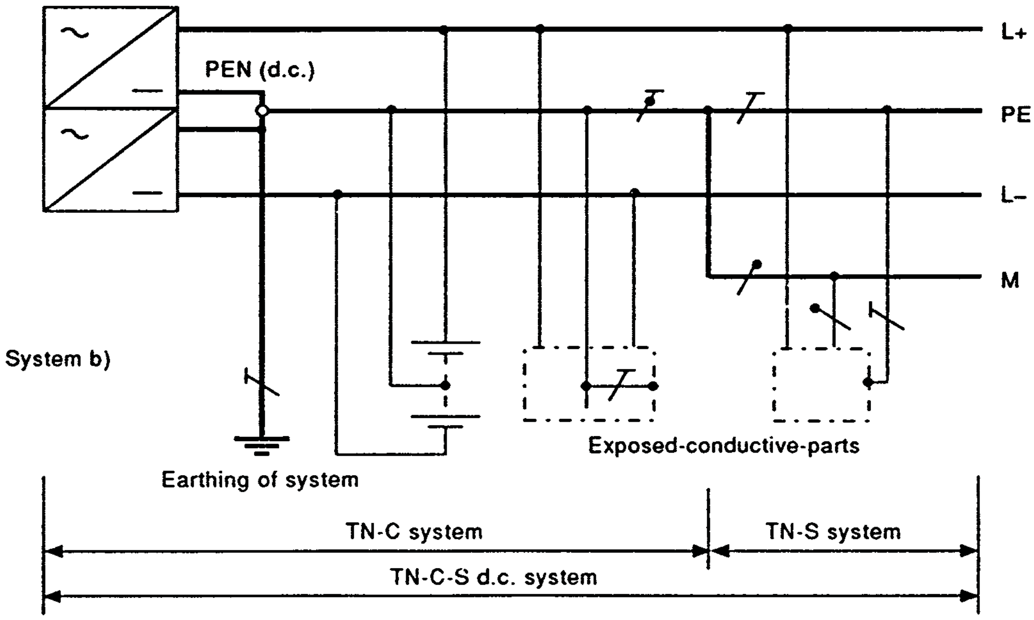
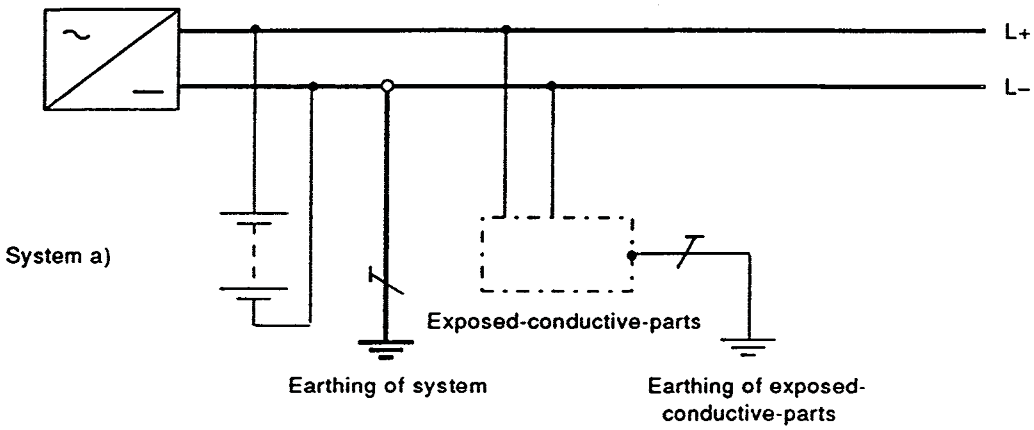


Figure 31-8 TN-C-S d.c. system

The functions of the earthed line conductor (for example L–) in system a) and protective conductor are combined in one single conductor PEN (d.c.) in parts of the system, or the earthed mid-wire conductor, M, in system b) and protective conductor are combined in one single conductor PEN (d.c.) in parts of the system.



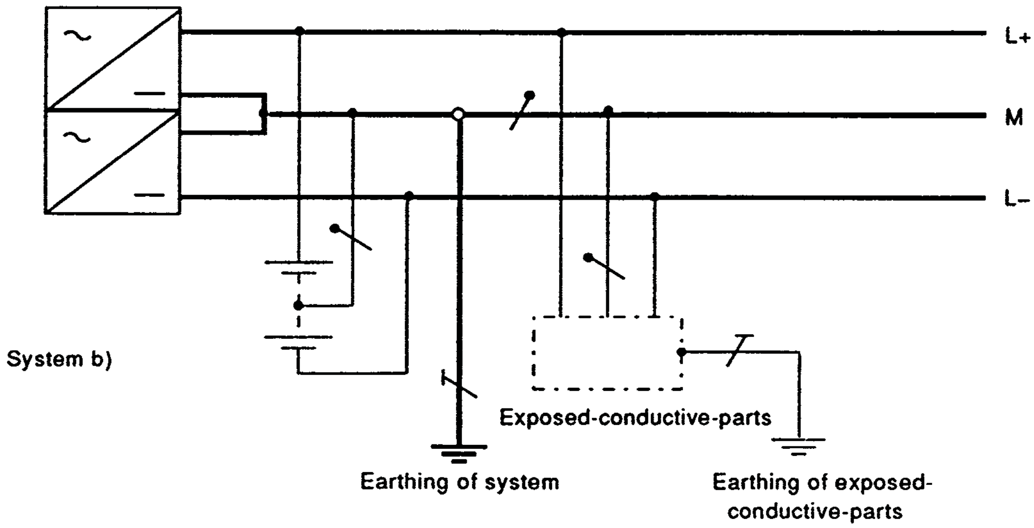


Figure 31-9 TT d.c. system

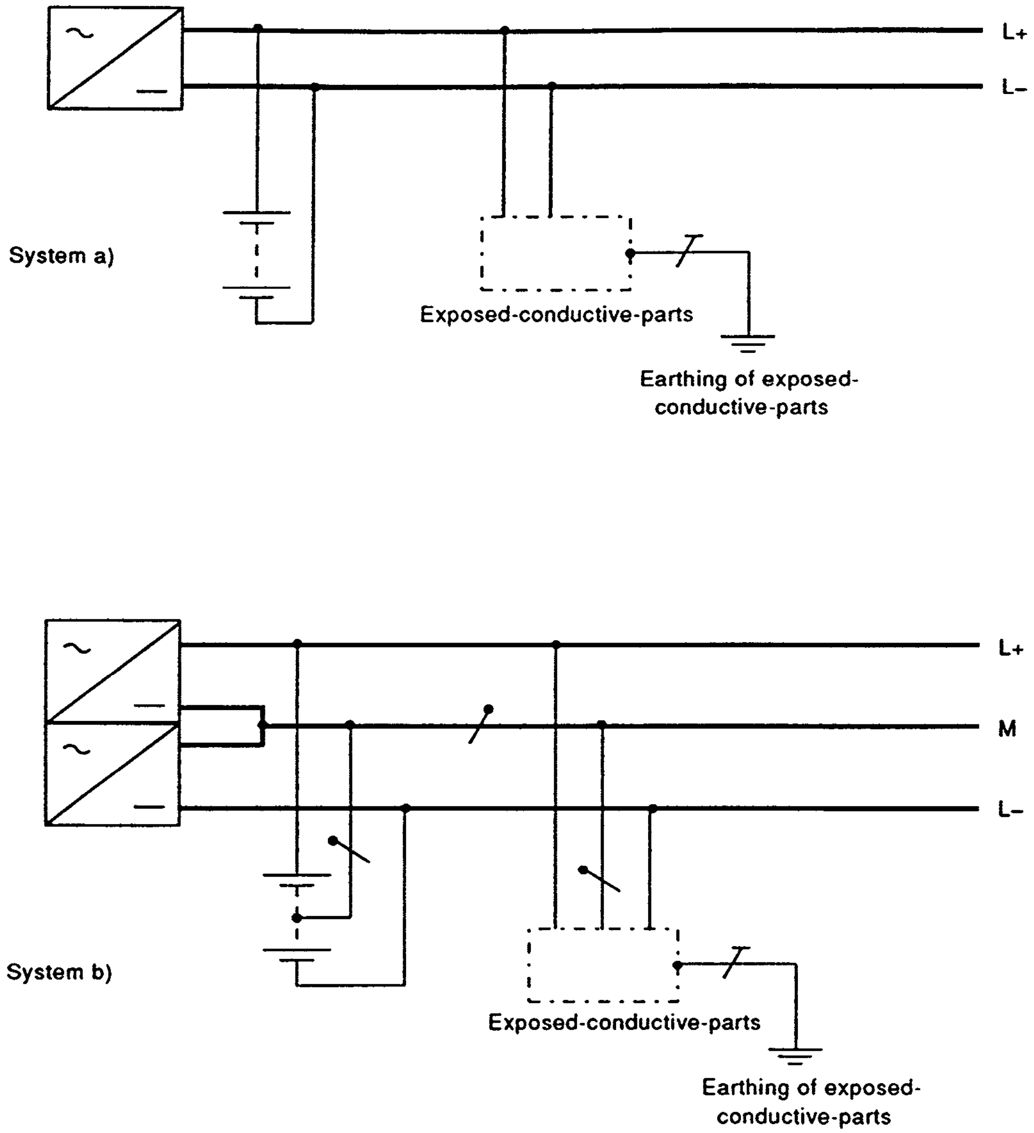


Figure 31-10 IT d.c. system

31-3 Supplies

31-3.1 General

31-3.1.1 The following characteristics of the available supply or supplies shall be assessed:

- nature of current and frequency;
- nominal voltage(s);
- prospective short-circuit current at the supply intake point;
- suitability for the requirements of the installation, including the maximum demand.

31-3.1.2 These characteristics shall be ascertained for an external supply and shall be determined for a private source. These requirements are equally applicable to main supplies and to safety services and standby supplies.

31-3.2 Supplies for safety services and standby systems

Where the provision of safety services is specified by the authorities concerned with fire precautions and other conditions for emergency evacuation of the premises, and/or where the provision of standby supplies is required by the any authority or person/body specifying the installation,

the characteristics of the sources of supply for safety services and/or standby systems shall be separately assessed. Such supplies shall have adequate capacity, reliability and rating and appropriate change-over time for the operation specified.

For further requirements for supplies for safety services see Chapter 32 hereafter and 55-6 of Chapter 55. For standby systems there are no particular requirements in these Electrical Requirements.

31-4 Division of installation

31-4.1 Every installation shall be divided into several circuits, as necessary, to

- avoid danger and minimize inconvenience in the event of a fault;
- facilitate safe inspection, testing, and maintenance (see also Chapter 53);
- take account of danger that may arise from the failure of a single circuit such as a lighting circuit.

31-4.2 Separate distribution circuits shall be provided for parts of the installation, which need to be separately controlled, in such a way that those circuits are not affected by failure of other circuits.

CHAPTER 32
COMPATIBILITY, MAINTAINABILITY AND SAFETY SERVICES

32-1 Compatibility

32-1.1 Compatibility of characteristics

An assessment shall be made of any characteristics of equipment likely to have harmful effects upon other electrical equipment or other services or likely to impair the supply. Those characteristics include, for example:

- transient overvoltages;
- rapidly fluctuating loads;
- starting currents;
- harmonic currents;
- d.c. feedback;
- high-frequency oscillations;
- earth leakage currents;
- necessity for additional connections to earth.

32-2.2 Electromagnetic compatibility

All electrical equipment shall meet the appropriate electromagnetic compatibility (EMC) requirements, and shall be in accordance with the relevant EMC standards.

Consideration shall be given by the planner and designer of the electrical installations to measures reducing the effect of induced overvoltages and EMI (Electromagnetic Interference).

Measures are given in Chapter 44.

32-2 Maintainability

32-2.1 An assessment shall be made of the frequency and quality of maintenance the installation can reasonably be expected to receive during its intended life. Where an authority is to be responsible for the operation of the installation, that authority shall be consulted. Those characteristics are to be taken into account in applying the requirements of PARTS FOUR to SIX of these Electrical Requirements so that, having regard to the frequency and quality of maintenance expected

- any periodic inspection and testing, maintenance and repairs likely to be necessary during the intended life can be readily and safely carried out; and
- the effectiveness of the protective measures for safety during the intended life is ensured; and
- the reliability of equipment for proper functioning of the installation is appropriate to the intended life.

32-3 Safety Services

32-3.1 General

NOTE The need for safety services and their nature are frequently regulated by statutory authorities whose requirements have to be observed.

The following sources for safety services are recognized:

- storage batteries;
- primary cells;
- generator sets independent of the normal supply;
- a separate feeder of the supply network effectively independent of the normal feeder (see 55-6.4.4 of Chapter 55).

PART FOUR

PROTECTION FOR SAFETY

CHAPTER 41
PROTECTION AGAINST ELECTRIC SHOCK

41-0.1 Scope

This Chapter describes how protection against electric shock is provided by application of the appropriate measures as specified in

- 41-1 for protection against both direct and indirect contact,
- 41-2 for protection against direct contact,
- 41-3 for protection against indirect contact.

41-0.3 Application of measures of protection against electric shock

41-0.3.1 General

41-0.3.1.1 Measures of protection shall be applied to every installation, part of an installation, and to equipment, as required by 41-0.3.

41-0.3.1.2 The choice and application of measures of protection according to conditions of external influence shall be as specified in 41-0.3.4.

41-0.3.1.3 Protection shall be ensured by:

- the equipment itself,
- application of a measure of protection as a process of erection,
- a combination of these two.

41-0.3.1.4 If certain conditions of a measure of protection are not satisfied, supplementary measures shall be taken to ensure, by such combined measures of protection the same degree of safety as complete compliance with those conditions.

NOTE An example of the application of this rule is given in 41-1.3.

41-0.3.1.5 It shall be ensured that there is no mutual detrimental influence between different measures of protection applied to the same installation or part of an installation.

41-0.3.2 Application of measures of protection against direct contact

41-0.3.2.1 All electrical equipment shall be subject to one of the measures of protection against direct contact described in 41-1 and 41-2.

41-0.3.2.2 The measures of protection by insulation of live parts (41-2.1) or by barriers or enclosures (41-2.2) are applicable in all conditions of external influences.

41-0.3.2.3 The measures of protection by means of obstacles (see 41-2.3) or placing out of reach (see 41-2.4) shall not be permitted in some installations and locations of increased shock risk (see the particular requirements of PART SEVEN).

41-0.3.3 Application of measures of protection against indirect contact

41-0.3.3.1 Except as provided in 41-0.3.3.5, all electrical equipment shall be subject to one of the measures of protection against indirect contact described in 41-1 and 41-3, and to the conditions given in 41-0.3.3.2 to 41-0.3.3.4.

41-0.3.3.2 Protection by automatic disconnection of supply (see 41-3.1) shall be applied to any installation, except to parts of the installation to which another measure of protection is applied.

41-0.3.3.3 Where the application of the requirements of 41-3.1 for protection by automatic disconnection of supply is impracticable or undesirable, protection by the provision of a non-conducting location (41-3.3) or earth-free local equipotential bonding (41-3.4) may be applied to certain parts of an installation.

41-0.3.3.4 Protection by SELV (Separated Extra-Low-Voltage) (41-1.1), by the use of class II equipment or equivalent insulation (41-3.2) and by electrical separation (41-3.5) may be applied in every installation, usually to certain equipment and certain parts of an installation.

41-0.3.3.5 Protection against indirect contact may be omitted for the following equipment:

- overhead line insulator wall brackets and metal parts connected to them (overhead line fittings) if they are not situated within arm's reach;
- steel reinforced concrete poles in which the steel reinforcement is not accessible;
- exposed-conductive-parts which, owing to their reduced dimensions (approximately 50 mm x 50 mm) or their disposition, cannot be gripped or come into significant contact with a part of the human body and provided that connection with a protective conductor could only be made with difficulty or would be unreliable;

  NOTE This requirement applies, for example, to bolts, rivets, nameplates and cable clips.
- metal tubes or other metal enclosures protecting equipment in accordance with 41-3.2.

41-0.3.4 Application of measures of protection in relation to external influences

41-0.3.4.1 The requirements of 41-0.3.4.2 indicate the measures for protection against electric shock defined in this Chapter are to be applied as a function of assessed conditions of external influences.

NOTE 1 In practice, only the following conditions of external influences are relevant to the selection of measures of protection against electric shock:

- BA: qualification of persons;
- BB: electrical resistance of the human body;
- BC: contact at persons with earth potential.

NOTE 2 Other conditions of external influences have practically no influence on the selection and implementation of measures of protection against electric shock, but should be taken into consideration for the selection of equipment (see Chapter 51, Table 51-1).

41-0.3.4.2 Where, for a given combination of external influences, several measures of protection are permitted, the selection of the appropriate measure depends on local conditions and the nature of the equipment concerned.

NOTE For special installations or special locations, see PART SEVEN.

41-0.3.4.3 The measure of protection by automatic disconnection of the supply according to 413.1 is applicable in any installation.

41-0.3.4.4 The measure of protection by use of class II equipment or by equivalent insulation, according to 41-3.2, is applicable in all situations, unless some limitations that are given in PART SEVEN.

NOTE For safety reasons it is important that the equipment be selected according to the external influences.

41-0.3.4.5 The measure of protection by non-conductive location is permitted in accordance with 41-3.3.

41-0.3.4.6 The measure of protection by earth-free local equipotential bonding is permitted only in the condition of external influences BC 1.

41-0.3.4.7 The measure of protection by electrical separation is applicable in all situations. However, in condition BC 4, it shall be limited to the supply of one item of mobile apparatus from one transformer.

41-0.3.4.8 The use of SELV (Separated Extra-Low-Voltage) according to 41-1.1.4, or PELV (Protective Extra-Low-Voltage) according to 41-1.1.5, is considered as a measure of protection against indirect contact in all situations.

NOTE 1 In certain cases, PART SEVEN limits the value of the ELV (Extra-Low Voltage) at a value lower than 50 V a.c (i.e. 25 V a.c. or 12 V a.c).

NOTE 2 The use of FELV (Functional Extra-Low-Voltage) requires another measure of protection against indirect contact (see 41-1.3.3).

41-0.3.4.9 In certain installations or parts of the installation, for example, in locations where persons may be immersed in water, the corresponding Chapters of PART SEVEN requires particular measures of protection.

41-1 Protection against both direct and indirect contact

41-1.1 SELV and PELV Systems

41-1.1.1 Protection against electric shock is deemed to be provided when

- the nominal voltage cannot exceed the upper limit of voltage band l 50V a.c. (see SASO IEC 60449),
- the supply is from one of the sources listed in 41-1.1.2,
- all the conditions of 41-1.1.3 and, in addition, either
- 41-1.1.4, for unearthed circuits (SELV), or
- 41-1.1.5, for earthed circuits (PELV) are fulfilled.

NOTE 1 If the system is supplied from a higher voltage system by other equipment such as auto-transformers, potentiometers, semiconductor devices, etc., the output circuit is deemed to be an extension of the input circuit and is protected the measures of protection are applied to the input circuit.

NOTE 2 For certain external influences, lower voltage limits may be required. See also PART SEVEN.

NOTE 3 In d.c. systems with batteries, the battery charging and floating voltages exceed the battery nominal voltage, depending on the type of battery. This does not require any measures of protection in addition to those specified in this statement. The charging voltage should not exceed a maximum value of 75 V a.c.or 150 V d.c. as appropriate, according to the environmental situation as given in Table 1 SASO IEC 61201.

41-1.1.2 Sources for SELV and PELV

41-1.1.2.1 A safety isolating transformer in accordance with SASO IEC 61558.

41-1.1.2.2 A source of current providing a degree of safety equivalent to that of the safety isolating transformer specified in 41-1.1.2.1 (e.g. motor generator with windings providing equivalent isolation).

41-1.1.2.3 An electrochemical source (e.g. a battery) or another source independent of a higher voltage circuit (e.g. a diesel-driven generator).

41-1.1.2.4 Certain electronic devices complying with appropriate standards where measures have been taken in order to ensure that, even in the case of an internal fault, the voltage at the outgoing terminals will not exceed the values specified in 41-1.1.1. Higher voltages at the outgoing terminals are, however, admitted if it is ensured that, in case of direct or indirect contact, the voltage at the output terminals is immediately reduced to those values or less.

NOTE 1 Examples of such devices include insulation testing equipment.

NOTE 2 Where higher voltages exist at the outgoing terminals, compliance with this statement may be assumed if the voltage at the outgoing terminals is within the limits specified in 41-1.1.1 when measured with a voltmeter having an internal resistance of at least 3 000 Ω.

41-1.1.2.5 Mobile sources, e.g. safety isolating transformers or motor generators, shall be selected or erected in accordance with the requirements for protection by the use of class II equipment or by equivalent insulation (see 41-3.2).

41-1.1.3 Arrangement of circuits

41-1.1.3.1 Live parts of SELV and PELV circuits shall be electrically separated from each other and from other circuits. Arrangements shall ensure electrical separation not less than that between the input and the output circuits of a safety isolating transformer.

NOTE 1 This requirement does not exclude the connection of the PELV circuit to earth (see 41-1.1.5).

NOTE 2 In particular, electrical separation not less than that provided between the input and the output windings of a safety isolating transformer is necessary between the live parts of electrical equipment such as relays, contactors, auxiliary switches and any part of a higher voltage circuit.

NOTE 3 DC voltages for SELV and PELV circuits generated by a semiconductor convertor (see SASO IEC 60146-2) require an internal a.c. voltage circuit to supply the rectifier stack. This internal a.c. voltage exceeds the d.c. voltage for physical reasons. This internal a.c. circuit is not to be considered as a "higher voltage circuit" within the meaning of this statement. Between internal circuits and external higher voltage, circuit protective separation (according to SASO IEC 61140) is required.

41-1.1.3.2 Circuit conductors of each SELV and PELV system shall preferably be physically separated from those of any other circuit conductors. When this requirement is impracticable, one of the following arrangements is required:

- SELV and PELV circuit conductors shall be enclosed in a non-metallic sheath in addition to their basic insulation;
- conductors of circuits at different voltages shall be separated by an earthed metallic screen or an earthed metallic sheath;

  NOTE In the above arrangements, basic insulation of any conductor need only be sufficient for the voltage of the circuit of which it is a part.
- circuits at different voltages may be contained in a multi-conductor cable or other grouping of conductors but the conductors of SELV and PELV circuits shall be insulated, individually or collectively, for the highest voltage present.

41-1.1.3.3 Plugs and socket-outlets for SELV and PELV systems shall comply with the following requirements:

- plugs shall not be able to enter socket-outlets of other voltage systems;
- socket-outlets shall not admit plugs of other voltage systems;
- socket-outlets shall not have a protective conductor contact.

41-1.1.4 Requirements for unearthed circuits (SELV)

41-1.1.4.1 Live parts of SELV circuits shall not be connected to earth or to live parts or to protective conductors forming part of other circuits.

41-1.1.4.2 Exposed-conductive-parts shall not be intentionally connected to:

- earth, or
- protective conductors or exposed-conductive-parts of another circuit, or
- extraneous conductive parts except that where electrical equipment is inherently required to be connected to extraneous conductive parts, it is ensured that those parts cannot attain a voltage exceeding the nominal voltage specified in 41-1.1.1.

NOTE If the exposed-conductive-parts of SELV circuits are liable to come into contact, either fortuitously or intentionally, with the exposed-conductive-parts of other circuits, protection against electric shock no longer depends solely on protection by SELV but also on the measures of protection to which the latter exposed-conductive-parts are subject.

41-1.1.4.3 If the nominal voltage exceeds 25 V a.c. or 60 V d.c. protection against direct contact shall be provided by:

- barriers or enclosures affording a degree of protection of at least IPXXB or IP2X, or
- insulation capable of withstanding a test voltage of 500 V a.c. for 1 min.

If the nominal voltage does not exceed 25 V a.c. or 60 V d.c., protection against direct contact is generally unnecessary; however, it may be necessary under certain conditions of external influences (see e.g. Chapter 701).

41-1.1.5 Requirements for earthed circuits (PELV)

Where the circuits are earthed and when SELV according to 41-1.1.4 is not required, the requirements of 41-1.1.5.1 and 41-1.1.5.2 shall be fulfilled.

41-1.1.5.1 Protection against direct contact shall be ensured by either:

- barriers or enclosures affording a degree of protection of at least IPXXB or IP2X, or
- insulation capable of withstanding a test voltage of 500 V a.c. for 1 min.

41-1.1.5.2 Protection against direct contact in compliance with 41-1.1.5.1 is not necessary within or outside a building where main equipotential bonding according to 41-3.1.2 is provided, and the earthing arrangement and exposed-conductive-parts of the PELV system are connected by a protective conductor to the main earthing terminal, and the nominal voltage does not exceed:

- 25 V a.c. or 60 V d.c. when the equipment is normally used in dry locations only and large-area contact of live parts with the human body is not to be expected;
- 6 V a.c. or 15 V d.c. in all other cases.

NOTE The earthing of circuits may be achieved by an appropriate connection to earth within the source itself.

41-1.3 FELV (Functional Extra-Low-Voltage) system

41-1.3.1 General

Where, for functional reasons, a voltage within band I is used but all the requirements of 41-1.1 relating to SELV or PELV are not fulfilled, and where SELV or PELV is not necessary, the supplementary measures described in 41-1.3.2 and 41-1.3.3 shall be taken to ensure protection against both direct and indirect contact. This combination of measures is known as FELV.

NOTE Such conditions may, for example, be encountered when the circuit contains equipment (such as transformers, relays, remote-control switches, contactors) insufficiently insulated with respect to circuits at higher voltage.

41-1.3.2 Protection against direct contact

Protection against direct contact shall be provided by either:

- barriers or enclosures in accordance with 41-2.2, or
- insulation corresponding to the minimum test voltage required for the primary circuit.

Where, however, the insulation of equipment which is part of a FELV circuit is not capable of withstanding the test voltage specified for the primary circuit, the insulation of accessible non-conductive parts of the equipment shall be reinforced during erection so that it can withstand a test voltage of 1500 V a.c. for 1 min.

41-1.3.3 Protection against indirect contact

Protection against indirect contact shall be provided by either:

- connection of the exposed-conductive-parts of the equipment of the FELV circuit to the protective conductor of the primary circuit, provided that the latter is subject to one of the measures of protection by automatic disconnection of supply described in 41-3.1; this does not preclude the connection of a live conductor of the FELV circuit to the protective conductor of the primary circuit, or
- connection of the exposed-conductive-parts of the equipment of the FELV circuit to the non-earthed equipotential bonding conductor of the primary circuit where protection by electrical separation in accordance with 41-3.5 is applied to the primary circuit.

41-1.3.4 Plugs and socket-outlets

Plugs and socket-outlets for FELV systems shall comply with the following requirements:

- plugs shall not be able to enter socket-outlets of other voltage systems, and
- socket-outlets shall not admit plugs of other voltage systems.

41-2 Protection against direct contact

41-2.1 Insulation of live parts

NOTE 1 The insulation is intended to prevent any contact with live parts.

Live parts shall be completely covered with insulation, which can only be removed by destruction.

For factory-built equipment, the insulation shall comply with the relevant Saudi Standards for the electrical equipment.

For other equipment, protection shall be provided by insulation capable of durably withstanding the stresses to which it may be subjected in service such as mechanical, chemical, electrical and thermal influences. Paints, varnishes, lacquers and similar products alone are generally not considered to provide adequate insulation for protection against electric shock in normal service.

NOTE 2 Where insulation is applied during the erection of the installation, the quality of the insulation should be confirmed by tests similar to those, which ensure the quality of insulation of similar factory-built equipment.

41-2.2 Barriers or enclosures

NOTE Barriers or enclosures are intended to prevent any contact with live parts.

41-2.2.1 Live parts shall be inside enclosures or behind barriers providing at least the degree of protection IPXXB or IP2X except that, where larger openings occur during the replacement of parts, such as certain lampholders, socket-outlets or fuses, or where larger openings are necessary to allow the proper functioning of equipment according to the relevant requirements for the equipment:

- suitable precautions shall be taken to prevent persons or livestock from unintentionally touching live parts; and
- it shall be ensured, as far as practicable, that persons are aware that live parts can be touched through the opening and should not be touched intentionally.

41-2.2.2 Horizontal top surfaces of barriers or enclosures which are readily accessible shall provide a degree of protection of at least IPXXD or IP4X.

41-2.2.3 Barriers and enclosures shall be firmly secured in place and have sufficient stability and durability to maintain the required degrees of protection and appropriate separation from live parts in the known conditions of normal service, taking account of relevant external influences.

41-2.2.4 Where it is necessary to remove barriers or open enclosures or to remove parts of enclosures, this shall be possible only:

- by the use of a key or tool, or
- after disconnection of the supply to live parts against which the barriers or enclosures afford protection, restoration of the supply being possible only after replacement or reclosure of the barriers or enclosures, or
- where an intermediate barrier providing a degree of protection of at least IPXXB or IP2X prevents contact with live parts, such a barrier being removable only by the use of a key or tool.

41-2.3 Obstacles

NOTE Obstacles are intended to prevent unintentional contact with live parts but not intentional contact by deliberate circumvention of the obstacle.

41-2.3.1 Obstacles shall prevent either:

- unintentional bodily approach to live parts, or
- unintentional contact with live parts during the operation of live equipment in normal service.

41-2.3.2 Obstacles may be removed without using a key or tool but shall be so secured as to prevent unintentional removal.

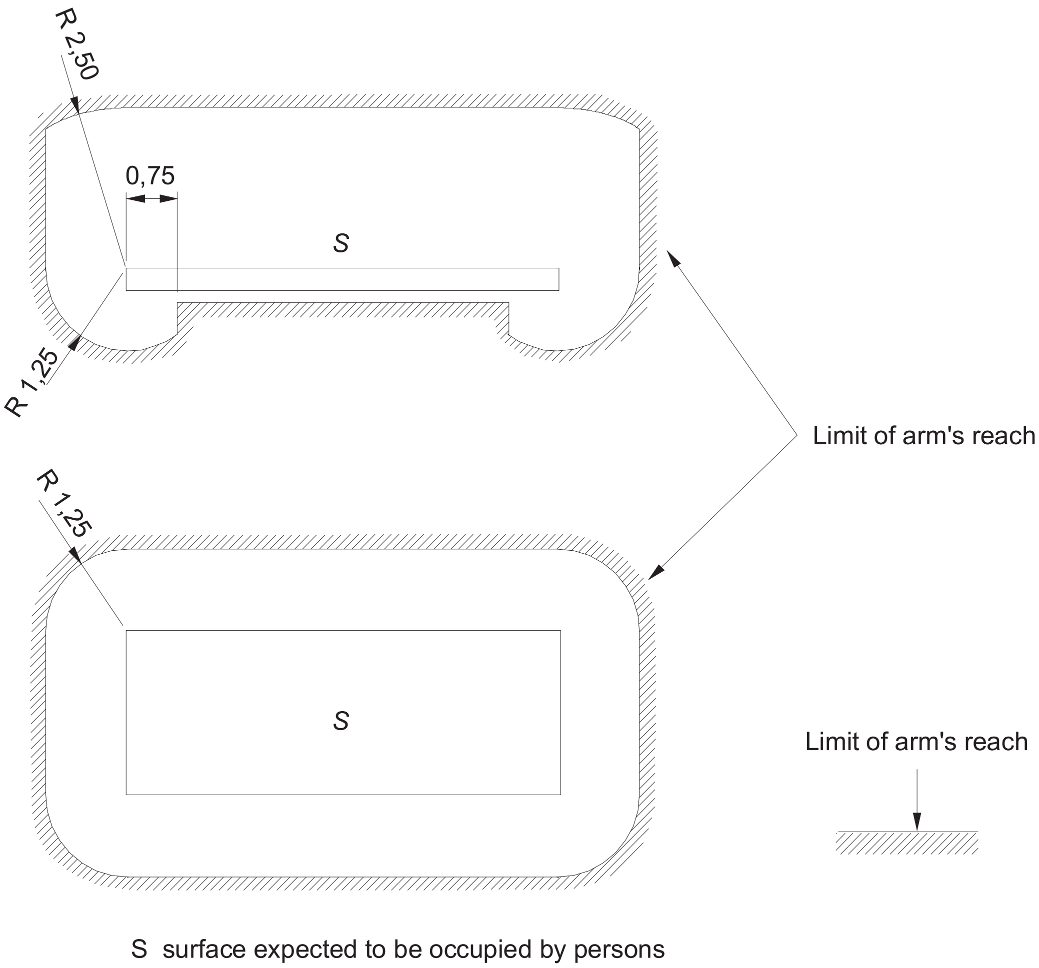
41-2.4 Placing out of reach

NOTE Protection by placing out of reach is intended only to prevent unintentional contact with live parts.

41-2.4.1 Simultaneously accessible parts at different potentials shall not be within arm's reach.

NOTE Two parts are deemed to be simultaneously accessible if they are not more than 2.50 m apart (see figure 41-1).

41-2.4.2 If a normally occupied position is restricted in the horizontal direction by an obstacle (e g. handrail, mesh screen) affording a degree of protection less than IPXXB or IP2X, arm's reach shall extend from that obstacle. In the overhead direction, arm's reach is 2.50 m from the surface *S* not taking into account any intermediate obstacle providing a degree of protection less than IPXXB or IP2X.



Dimensions in metres

Figure 41-1 Zone of arm's reach

NOTE The values of arm's reach apply to contact directly with bare hands without assistance (e.g. tools or ladder).

41-2.4.3 In places where bulky or long conductive objects are normally handled, the distances required by 41-2.4.1 and 41-2.4.2 shall be increased taking account of the relevant dimensions of those objects.

41-2.5 Additional protection by residual current devices (RCDs)

NOTE The use of residual current devices (RCDs) is intended only to augment extra measures of protection against direct contact.

41-2.5.1 The use of residual current devices (RCDs) with a rated operating residual current not exceeding 30 mA, is recognized as additional protection in case of direct contact in the event of failure of other measures of protection or carelessness by users.

41-2.5.2 The use of such devices is not recognized as a sole means of protection and does not obviate the need to apply one of the measures of protection specified in 41-2.1 to 41-2.4.

41-2.5.3 Where protection is provided by automatic disconnection of supply, residual current protective devices with rated residual operating current not exceeding 30 mA shall be used on each circuit feeding socket-outlets with rated current not exceeding 20 A located according to the following conditions:

- Socket-outlets located within wet areas such as bathrooms, kitchens and washing rooms,
- Socket-outlets for temporary installations,
- Socket-outlets located outdoors,
- Socket-outlets supplying portable equipment for use outdoors.

NOTE 1 Where an installation is to provide for the use of portable equipment to be used outdoors, it is recommended that one or more socket-outlets, as necessary, be suitably located outdoors.

NOTE 2 Other cases where devices with rated residual operating current not exceeding 30 mA are required are described in PART SEVEN and 55-8.

NOTE 3 Where protection is provided by automatic disconnection of supply, the use of residual current protective devices with rated residual operating current not exceeding 30 mA is particularly recommended to provide additional protection according to 41-2.5 to protect socket-outlets having rated current not exceeding 20 A intended to be used by other than skilled or instructed persons.

41-3 Protection against indirect contact

41-3.1 Automatic disconnection of supply

NOTE 1 Automatic disconnection of supply is required where a risk of harmful patho-physiological effects in a person could arise, when a fault occurs, due to the value and duration of the touch voltage (see SASO 1774).

NOTE 2 This measure of protection necessitates co-ordination of the type of system earthing and the characteristics of protective conductors and protective devices.

An explanation of the derivation of the requirements of this measure of protection as well as reference curves derived from SASO 1774 are provided in SASO IEC/TR 61200-413.

41-3.1.1 General

NOTE Conventional means of compliance with 41-3.1.1.1 and 41-3.1.1.2 are given in 41-3.1.3 to 41-3.1.5, according to the type of system earthing.

41-3.1.1.1 Disconnection of supply

A protective device shall automatically disconnect the supply to the circuit or equipment for which the device provides protection against indirect contact so that, in the event of a fault between a live part and an exposed conductive part or a protective conductor in the circuit or equipment, a prospective touch voltage exceeding 50 V a.c. or 120 V d.c. does not persist for a time sufficient to cause a risk of harmful physiological effect in a person in contact with simultaneously accessible conductive parts.

Irrespective of the touch voltage, a disconnecting time not exceeding 5 s is permitted under certain circumstances depending on the type of system earthing.

NOTE 1 Higher values of disconnecting time and voltage than those required in this statement may be admitted in systems for electric power generation and distribution.

NOTE 2 Lower values of disconnecting time and voltage may be required for special installations or locations according to the relevant chapters of PART SEVEN and 41-3.3.

NOTE 3 For IT systems, automatic disconnection is not usually required on the occurrence of a first fault (see 41-3.1.5).

41-3.1.1.2 Earthing

Exposed-conductive-parts shall be connected to a protective conductor under the specific conditions for each type of system earthing.

Simultaneously accessible exposed-conductive-parts shall be connected to the same earthing system individually, in groups or collectively.

NOTE For earthing arrangements and protective conductors see Chapter 54.

41-3.1.2 Equipotential bonding

41-3.1.2.1 Main equipotential bonding

In each building, the following conductive parts shall be connected to the main equipotential bonding:

- main protective conductor;
- main earthing conductor or main earthing terminal;
- pipes supplying services within the building, e.g. gas, water;
- structural metallic parts, central heating and air-conditioning systems, if applicable.

Such conductive parts originating outside the building shall be bonded as close as practicable to their point of entry within the building.

Main equipotential conductors shall comply with Chapter 54.

The main equipotential bonding shall be made to any metallic sheath of telecommunication cables. However, the consent of the owners or operators of these cables shall be obtained.

41-3.1.2.2 Supplementary equipotential bonding

If the conditions for automatic disconnection stated in 41-3.1.1.1 cannot be fulfilled in an installation or part of an installation, a local bonding known as supplementary equipotential bonding (see 41-3.1.6) shall be applied.

NOTE 1 The use of supplementary equipotential bonding does not exclude the need to disconnect the supply for other reasons, for example protection against fire, thermal stresses in equipment, etc.

NOTE 2 Supplementary equipotential bonding may involve the entire installation, a part of the installation, an item of apparatus or a location.

NOTE 3 Additional requirements may be necessary for special locations, see Chapter 54.

41-3.1.3 TN systems

41-3.1.3.1 All exposed-conductive-parts of the installation shall be connected to the earthed point of the power system by protective conductors, which shall be earthed at or near each relevant transformer or generator.

Generally the earthed point of the power system will be the neutral point. If a neutral point is not available or not accessible, a phase conductor shall be earthed. In no case, shall the phase conductor serve as a PEN conductor (see 41-3.1.3.2).

NOTE 1 If other effective earth connections exist, it is recommended that the protective conductors also be connected to such points wherever possible. Earthing at additional points, distributed as evenly as possible, may be necessary to ensure

that the potentials of protective conductors remain, in case of a fault, as near as possible to that of earth.
In large buildings such as high-rise buildings, additional earthing of protective conductors is not possible for practical reasons. Equipotential bonding between protective conductors and extraneous conductive parts has, however, a similar function in this case.

NOTE 2 For the same reason, it is recommended that protective conductors should be earthed where they enter any buildings or premises.

41-3.1.3.2 In fixed installations a single conductor may serve both as a protective conductor and neutral conductor (PEN conductor) provided that the requirements of 54-6.2 of Chapter 54 are satisfied. The PEN conductor shall not be isolated or switched.

41-3.1.3.3 The characteristics of protective devices (see 41-3.1.3.8) and the circuit impedances shall be such that, if a fault of negligible impedance occurs anywhere in the installation between a phase conductor and a protective conductor or exposed conductive part, automatic disconnection of the supply will occur within the specified time, the following condition fulfilling this requirement:

$$Z_S \times I_a \leq U_O$$

Where

Z_S is the impedance, in ohms, of the fault loop comprising the source, the live conductor up to the point of the fault and the protective conductor between the point of the fault and the source;

I_a is the current, in amperes, causing the automatic operation of the disconnecting protective device within the time stated in table 41-1 as a function of the nominal voltage U_O, or under the condition stated in 41-3.1.3.5, within a conventional time not exceeding 5 s;

U_O is the nominal a.c. voltage, in volts, to earth.

Table 41-1 Maximum disconnecting times for TN systems

U_O V	**Disconnecting time** S
127	0.8
220	0.4
* Values based on SASO 182	

41-3.1.3.4 The maximum disconnecting times stated in Table 41-1 are deemed to satisfy 41-3.1.1.1 for final circuits which supply, through socket-outlets or directly without socket-outlets, class I hand-held equipment or portable equipment.

41-3.1.3.5 A conventional disconnecting time not exceeding 5 s is permitted for distribution circuits.

A disconnecting time exceeding that required by Table 41-1 but not exceeding 5 s is permitted for a final circuit supplying stationary equipment only, provided that, where other final circuits which require disconnecting times according to Table 41-1 are connected to the distribution board, or distribution circuit supplying that final circuit, one of the following conditions is fulfilled:

a) the impedance, in ohms, of the protective conductor between the distribution board and the point at which the protective conductor is connected to the main equipotential bonding does not exceed

$$\frac{50}{U_o} Z_s \ (\Omega)$$

or

b) there is equipotential bonding at the distribution board which involves the same types of extraneous conductive parts as the main equipotential bonding and which complies with the requirements for main equipotential bonding in 41-3.1.2.1.

41-3.1.3.6 lf the conditions of 41-3.1.3.3, 41-3.1.3.4 and 41-3.1.3.5 cannot be fulfilled by using overcurrent protective devices, supplementary equipotential bonding in accordance with 41-3.1.2.2 shall be applied. Alternatively, protection shall be provided by means of a residual current protective device.

41-3.1.3.7 In exceptional cases where a fault may occur between a phase conductor and earth, for example in the use of overhead lines, the following condition shall be fulfilled in order that the protective conductor and the exposed-conductive-parts connected to it do not reach a voltage to earth exceeding a conventional value of 50 V:

$$\frac{R_B}{R_E} \leq \frac{50}{U_o - 50}$$

Where

R_B is the earth electrode resistance, in ohms, of all earth electrodes in parallel;

R_E is the minimum contact resistance with earth, in ohms, of extraneous conductive parts not connected to a protective conductor, through which a fault between phase and earth may occur;

U_o is the nominal a.c. voltage to earth, in volts.

41-3.1.3.8 In TN systems, use of the following protective devices is recognized:

- overcurrent protective devices;
- residual current protective devices;

except that

- a residual current protective device shall not be used in TN-C systems;
- where a residual current protective device is used in a TN-C-S system, a PEN conductor shall not be used on the load side. The connection of the protective conductor to the PEN conductor shall be made on the source side of the residual current protective device.

41-3.1.4 TT systems

41-3.1.4.1 All exposed-conductive-parts collectively protected by the same protective device shall be connected, together with the protective conductors, to an earth electrode common to all those parts. Where several protective devices are utilized in series, this requirement applies separately to all the exposed-conductive-parts protected by each device.

The neutral point or, if it does not exist, a phase conductor of each generator station or transformer station shall be earthed.

41-3.1.4.2 The following condition shall be fulfilled:

$$R_A \times I_a \leq 50 \text{ V}$$

Where

R_A is the sum of the resistance, in ohms, of the earth electrode and the protective conductor for the exposed conductive parts;

I_a is the current, in amperes, causing the automatic operation of the protective device.

When the protective device is a residual current protective device, I_a is the rated residual operating current $I_{\Delta n}$.

For the purpose of discrimination, S-type residual current protective devices (see SASO IEC 61008-1 and SASO IEC 61009-1) may be used in series with general type residual current protective devices. To provide discrimination with S-type residual current protective devices, an operating time not exceeding 1 s is permitted in distribution circuits.

When the protective device is an overcurrent protective device, it shall be either:

- a device with an inverse time characteristic and I_a shall be the current, in amperes, causing automatic operation within 5 s, or
- a device with an instantaneous tripping characteristic and I_a shall be the minimum current, in amperes, causing instantaneous tripping.

41-3.1.4.3 If the condition of 41-3.1.4.2 cannot be fulfilled; supplementary equipotential bonding in accordance with 41-3.1.2.2 and 41-3.1.6 shall be applied.

41-3.1.4.4 In TT systems, use of the following devices is recognized:

- residual current protective devices;
- overcurrent protective devices.

NOTE 1 Overcurrent protective devices are only applicable for protection against indirect contact in TT systems where a very low value of R_A exists.

NOTE 2 The use of fault-voltage operated protective devices is not excluded for special applications where the above-mentioned protective devices cannot be used.

41-3.1.5 IT systems

41-3.1.5.1 In IT systems, the installation shall be insulated from earth or connected to earth through a sufficiently high impedance. This connection may be made either at the neutral point of the system or at an artificial neutral point. The latter may be connected directly to earth if the resulting zero-sequence impedance is sufficiently high. Where no neutral point exists, a phase conductor may be connected to earth through an impedance.

The fault current is then low in the event of a single fault to an exposed conductive part or to earth and disconnection is not imperative, provided the condition in 41-3.1.5.3, is fulfilled. Measures shall be taken, however, to avoid risk of harmful patho-physiological effects on a person in contact with simultaneously accessible conductive parts in the event of two faults existing simultaneously.

41-3.1.5.2 No live conductor of the installation shall be directly connected to earth.

NOTE To reduce overvoltage or to damp voltage oscillation, it may be necessary to provide earthing through impedances or artificial neutral points, and the characteristics of these should be appropriate to the requirements of the installation.

41-3.1.5.3 Exposed-conductive-parts shall be earthed individually, in groups or collectively.

NOTE In large buildings, such as high rise buildings, the direct connection of protective conductors to an earth electrode is not possible for practical reasons. Earthing of exposed-conductive-parts may be achieved by bonding between protective conductors, exposed-conductive-parts and extraneous-conductive-parts.

The following condition shall be fulfilled:

$$R_A \times I_d \leq 50 \text{ V}$$

Where

R_A is the resistance, in ohms, of the earth electrode for exposed-conductive-parts;

I_d is the fault current, in amperes, of the first fault of negligible impedance between a phase conductor and an exposed conductive part. The value of I_d takes account of leakage currents and the total earthing impedance of the electrical installation.

41-3.1.5.4 In cases where an IT system is used for reasons of continuity of supply, an insulation monitoring device shall be provided to indicate the occurrence of a first fault from a live part to exposed-conductive-parts or to earth. This device shall initiate an audible and/or visual signal.

If there are both audible and visible signals, it is permissible for the audible signal to be cancelled, but the visual alarm shall continue as long as the fault persists.

NOTE It is recommended that a first fault be eliminated with the shortest practicable delay.

41-3.1.5.5 After the occurrence of a first fault, conditions for disconnection of supply in the event of a second fault shall be as follows, whether all exposed-conductive-parts are interconnected by a protective conductor (collectively earthed) or are earthed in groups or individually:

a) where exposed-conductive-parts are earthed in groups or individually, conditions for protection are given in 41-3.1.4 as for TT systems, except that the second paragraph of 41-3.1.4.1 does not apply;

b) where exposed-conductive-parts are interconnected by a protective conductor collectively earthed, the conditions of a TN system apply subject to 41-3.1.5.6.

41-3.1.5.6 The following conditions shall be fulfilled where the neutral is not distributed:

$$Z_s \leq \frac{\sqrt{3} \times U_o}{2\ I_a}$$

or where the neutral is distributed:

$$Z'_s \leq \frac{U_o}{2\ I_a}$$

Where

U_o is the nominal a.c. r.m.s. voltage, in volts, between phase and neutral;

U is the nominal a.c. r.m.s. voltage, in volts, between phases;

Z_S is the impedance, in ohms, of the fault loop comprising the phase conductor and the protective conductor of the circuit;

Z'_s is the impedance, in ohms, of the fault loop comprising the neutral conductor and the protective conductor of the circuit;

I_a is the operating current in amperes of the protection device in the disconnecting time t specified in Table 41-2 when applicable, or within 5 s for all other circuits when this time is allowed.

Table 41-2 Maximum disconnecting times in IT systems (second fault)

Installation nominal voltage U_o/U V	Disconnecting time S	
	Neutral not distributed	Neutral distributed
127/220	0.8	5
220/380	0.4	0.8

41-3.1.5.7 In IT systems use of the following monitoring and protective devices is recognized:

- insulation monitoring devices;
- overcurrent protective devices;
- residual current protective devices.

41-3.1.6 Supplementary equipotential bonding

41-3.1.6.1 Supplementary equipotential bonding shall include all simultaneously accessible exposed-conductive-parts of fixed equipment and extraneous conductive parts including, where practicable, the main metallic reinforcement of constructional reinforced concrete. The equipotential system shall be connected to the protective conductors of all equipment including those of socket-outlets.

41-3.1.6.2 Where doubt exists regarding the effectiveness of supplementary equipotential bonding, it shall be confirmed that the resistance R between simultaneously accessible exposed-conductive-parts and extraneous conductive parts fulfills the following condition:

$$R \leq \frac{50}{I_a}$$

Where:

I_a is the operating current, in amperes, of the protective device:

- for residual current devices, $I_{\Delta n}$
- for overcurrent devices, the 5 s operating current.

41-3.1.7 Requirements related to conditions of external influence

In general, the conditions of 41-3.1 apply.

In the installation or parts of the installation for which the corresponding chapter of PART SEVEN (e.g. 704 or 705) limits the conventional touch voltage to 25 V a.c. or 60 V d.c., one of the requirements of 41-3.1.7.1 or 41-3.1.7.2 apply.

NOTE 1 The requirements of 41-3.1.7.1 apply when the reduced conventional touch voltage is applicable to a complete installation.

NOTE 2 One of the requirements of 41-3.1.7.2 applies when the reduced conventional touch voltage is applicable only to a part of an installation.

41-3.1.7.1 In the installation for which the corresponding chapter of Part Seven (e.g. 704 or 705) limits the conventional touch voltage to 25 V a.c. or 60 V d.c., the following requirements apply:

- in TT and IT systems, the maximum disconnecting times defined in Tables 41-1 and 41-2 shall be replaced by the following::

Table 41-3 Maximum disconnecting times

TN system		IT system		
Installation nominal voltage	**Disconnecting time**	**Installation nominal voltage**	**Disconnecting time** S	
U_o [a] V	S	U_o/U V	**Neutral not distributed**	**Neutral distributed**
127	0.35	127/220	0.4	1
220	0.2	220/380	0.2	0.5

[a] U_o is the voltage between phase and neutral

- in TT systems, the condition of 41-3.1.4.2 is replaced by the following:

$$R_A \text{ x } I_a \le 25 \text{ V}$$

- in IT systems, the condition of 41-3.1.5.3 is replaced by the following:

$$R_A \text{ x } I_d \le 25 \text{ V}$$

41-3.1.7.2 In the parts of the installation in which the corresponding chapter of PART SEVEN limits the conventional touch voltage to 25 V a.c. or 60 V d.c., the rules of 41-3.1 may be applied if one of the following measures is taken:

- application of supplementary equipotential bonding according to the conditions of 41-3.1.6, the value 50 in the formula of 41-3.1.6.2 being replaced by 25;
- protection by residual-current devices, the rated residual operating current of which is not more than 30 mA.

NOTE The conditions of this statement provide protection for the whole installation, in accordance with the general conditions of 41-3.1 and also in accordance with the requirements of PART SEVEN for supplementary protection in special locations where these requirements call for a limitation of touch voltage.

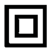
41-3.2 Class II equipment or equivalent insulation

NOTE This measure is intended to prevent the appearance of dangerous voltage on the accessible parts of electrical equipment through a fault in the basic insulation.

41-3.2.1 Protection shall be provided either by electrical equipment, or supplementary insulation or reinforced insulation, as described below.

41-3.2.1.1 Electrical equipment of the following types, type tested and marked to the relevant standards:

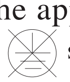
- electrical equipment having double or reinforced insulation (class II equipment);
- factory-built assemblies of electrical equipment having total insulation (see SASO 1609, SASO 1610, SASO 1611, and SASO 1988).

NOTE This equipment is identified by the symbol .

41-3.2.1.2 Supplementary insulation applied to electrical equipment having basic insulation only, in the process of erecting an electrical installation, providing a degree of safety equivalent to electrical equipment according to 41-3.2.1.1 and complying with 41-3.2.2 to 41-3.2.6.

NOTE The symbol  should be fixed in a visible position on the exterior and interior of the enclosure.

41-3.2.1.3 Reinforced insulation applied to uninsulated live parts, as a process in the erection of an electrical installation, providing a degree of safety equivalent to electrical equipment according to 41-3.2.1.1 and complying with 41-3.2.3 to 41-3.2.6; such insulation being recognized only where constructional features prevent the application of double insulation.

NOTE The symbol  should be fixed in a visible position on the exterior and interior of the enclosure.

41-3.2.2 The electrical equipment being ready for operation, all conductive parts separated from live parts by basic insulation only shall be contained in an insulating enclosure affording at least the degree of protection IPXXB or IP2X.

41-3.2.3 The insulating enclosure shall be capable of resisting mechanical, electrical or thermal stresses likely to occur.

Coatings of paint, varnish and similar products are generally not considered to comply with these requirements. This requirement does not exclude, however, the use of a type-tested enclosure provided with such coatings if

the relevant standards admit their use and if the insulating coatings are tested according to the relevant test conditions.

NOTE For requirements for creepage distances and clearances, see SASO IEC 60664.

41-3.2.4 If the insulating enclosure, has not previously been tested and doubt exists regarding its effectiveness, an electric strength test shall be carried out in accordance with the conditions specified in PART SIX.

41-3.2.5 The insulating enclosure shall not be traversed by conductive parts likely to transmit a potential. The insulating enclosure shall not contain any screws or insulating material the replacement of which by metallic screws could impair the insulation provided by the enclosure.

NOTE Where the insulating enclosure must be traversed by mechanical joints or connections (e.g. for operating handles of built-in apparatus), these should be arranged in such a way that protection against shock in case of a fault is not impaired.

41-3.2.6 Where lids or doors in the insulating enclosure can be opened without the use of a tool or key, all conductive parts which are accessible if the lid or door is open shall be behind an insulating barrier providing a degree of protection not less than IPXXB or IP2X which prevents persons from coming unintentionally into contact with those parts. This insulating barrier shall be removable only by use of a tool.

41-3.2.7 Conductive parts enclosed in the insulating enclosure shall not be connected to a protective conductor. However, provision may be made for connecting protective conductors, which necessarily run through the enclosure in order to serve other items of electrical equipment whose supply circuit also runs through the enclosure. Inside the enclosure, any such conductors and their terminals shall be insulated as though they were live parts, and their terminals shall be appropriately marked.

Exposed-conductive-parts and intermediate parts shall not be connected to a protective conductor unless specific provision for this is made in the specifications for the equipment concerned.

41-3.2.8 The enclosure shall not adversely affect the operation of the equipment protected in this way.

41-3.2.9 The installation of equipment mentioned in 41-3.2.1.1 (fixing, connection of conductors, etc.) shall be effected in such a way as not to impair the protection afforded in compliance with the equipment specification.

41-3.3 Non-conducting location

NOTE This protective measure is intended to prevent simultaneous contact with parts, which may be at different potential through failure of the basic insulation of live parts.

The use of class 0 equipment is recognized if all the following conditions are fulfilled:

41-3.3.1 Exposed-conductive-parts shall be arranged so that under ordinary circumstances persons will not come into simultaneous contact with

a) two exposed-conductive-parts, or

b) an exposed conductive part and any extraneous conductive part.

If these parts are liable to be at different potential through failure of the basic insulation of live parts.

41-3.3.2 In a non-conducting location there shall be no protective conductor.

41-3.3.3 The statement 41-3.3.1 is fulfilled if the location has an insulating floor and walls and one or more of the following arrangements applies:

a) Relative spacing of exposed-conductive-parts and of extraneous conductive parts as well as spacing of exposed-conductive-parts. This spacing is sufficient if the distance between two parts is not less than

2 m; this distance may be reduced to 1.25 m out of the zone of arm's reach.

b) Interposition of effective obstacles between exposed-conductive-parts and extraneous conductive parts. Such obstacles are sufficiently effective if they extend the distances to be surmounted to the values stated in paragraph a) above. They shall not be connected to earth or to exposed-conductive-parts; as far as possible they shall be of insulating material.

c) Insulation or insulating arrangements of extraneous conductive parts. The insulation shall be of sufficient mechanical strength and be able to withstand a test voltage of at least 2 000 V. Leakage current shall not exceed 1 mA in normal conditions of use.

41-3.3.4 The resistance of insulating floors and walls at every point of measurement under the conditions specified in PART SIX shall be not less than

- 50 kΩ, where the nominal voltage of the installation does not exceed 500 V, or
- 100 kΩ, where the nominal voltage of the installation exceeds 500 V.

NOTE If at any point the resistance is less than the specified value, the floors and walls are deemed to be extraneous conductive parts for the purposes of protection against shock.

41-3.3.5 The arrangements made shall be permanent and it shall not be possible to make them ineffective. They shall also ensure protection where the use of mobile or portable equipment is envisaged.

NOTE 1 Attention is drawn to the risk that where electrical installations are not under effective supervision, further conductive parts may be introduced at a later date (e.g. mobile or portable class I equipment or extraneous conductive parts such as metallic water pipes), which may invalidate compliance with 41-3.3.5.

NOTE 2 It is essential to ensure that the insulation of floor and walls cannot be affected by humidity.

41-3.3.6 Precautions shall be taken to ensure that extraneous conductive parts cannot cause a potential to appear externally to the location concerned.

41-3.4 Protection by earth-free local equipotential bonding

NOTE Earth-free local equipotential bonding is intended to prevent the appearance of a dangerous touch voltage.

41-3.4.1 Equipotential bonding conductors shall interconnect all simultaneously accessible exposed-conductive-parts and extraneous conductive parts.

41-3.4.2 The local equipotential bonding system shall not be in electrical contact with earth directly through exposed-conductive-parts or through extraneous conductive parts.

NOTE Where this requirement cannot be fulfilled, protection by automatic disconnection of supply is applicable (see 41-3.1).

41-3.4.3 Precautions shall be taken to ensure that persons entering the equipotential location cannot be exposed to a dangerous potential difference; in particular, where a conductive floor insulated from earth is connected to the earth-free equipotential bonding system.

41-3.5 Electrical separation

NOTE Electrical separation of an individual circuit is intended to prevent shock currents through contact with exposed-conductive-parts, which may be energized by a fault in the basic insulation of the circuit.

41-3.5.1 Protection by electrical separation shall be ensured by compliance with all the requirements of Sections 41-3.5.1.1 to 41-3.5.1.5 and with:

- 41-3.5.2, for the supply of one item of apparatus, or
- 41-3.5.3, for the supply of more than one item of apparatus.

NOTE It is recommended that the product of the nominal voltage of the circuit in volts and length in metres of the wiring system should not exceed 100 000, and that the length of the wiring system should not exceed 500 m.

41-3.5.1.1 The circuit shall be supplied through a separation source i.e.

- an isolating transformer, or
- a source of current providing a degree of safety equivalent to that of the isolating transformer specified above, for example a motor generator with windings providing equivalent isolation.

NOTE Ability to withstand a particularly high test voltage is recognized as a means of ensuring the necessary degree of isolation.

Mobile sources of supply connected to a supply system shall be selected or installed in accordance with 41-3.2.

Fixed sources of supply shall be either:

- selected and installed in accordance with 41-3.2, or
- such that the output is separated from the input and from the enclosure by an insulation satisfying the conditions of 41-3.2; if such a source supplies several items of equipment, the exposed-conductive-parts of that equipment shall not be connected to the metallic enclosure of the source.

41-3.5.1.2 The voltage of the electrically separated circuit shall not exceed 500 V.

41-3.5.1.3 Live parts of the separated circuit shall not be connected at any point to another circuit or to earth.

To avoid the risk of a fault to earth, particular attention shall be given to the insulation of such parts from earth, especially for flexible cables and cords.

Arrangements shall ensure electrical separation not less than that between the input and output of an isolating transformer.

NOTE In particular the electrical separation is necessary between the live parts of electrical equipment such as relays, contactors, auxiliary switches and any part of another circuit.

41-3.5.1.4 Flexible cables and cords shall be visible throughout any part of their length liable to mechanical damage.

41-3.5.1.5 For separated circuits, the use of separate wiring systems is recommended. If the use of conductors of the same wiring system for separated circuits and other circuits is unavoidable, multi-conductor cables without metallic covering, or insulated conductors in insulating conduit, ducting or trunking shall be used, provided that their rated voltage is not less than the highest voltage likely to occur, and that each circuit is protected against overcurrent.

41-3.5.2 Where a single item of apparatus is supplied, the exposed-conductive-parts of the separated circuit shall not be connected either to the protective conductor or exposed-conductive-parts of other circuits.

NOTE If the exposed-conductive-parts of the separated circuit are liable to come into contact, either intentionally or fortuitously, with the exposed-conductive-parts of other circuits, protection against electric shock no longer depends solely on protection by electrical separation but on the protective measures to which the latter exposed-conductive-parts are subject.

41-3.5.3 If precautions are taken to protect the separated circuit from damage and insulation failure, a source of supply, complying with 41-3.5.1.1, may supply more than one item of apparatus provided that all the requirements of 41-3.5.3.1 to 41-3.5.3.4 are fulfilled.

41-3.5.3.1 The exposed-conductive-parts of the separated circuit shall be connected together by insulated non-earthed equipotential bonding conductors. Such conductors shall not be connected to the protective conductors or exposed-conductive-parts of other circuits or to any extraneous conductive parts.

NOTE See note to 41-3.5.2.

41-3.5.3.2 All socket-outlets shall be provided with protective contacts, which shall be connected to the equipotential bonding system provided in accordance with 41-3.5.3.1.

41-3.5.3.3 Except where supplying class II equipment, all flexible cables shall embody a protective conductor for use as an equipotential bonding conductor.

41-3.5.3.4 It shall be ensured that if two faults affecting two exposed-conductive-parts occur and these are fed by conductors of different polarity, a protective device shall disconnect the supply in a disconnecting time conforming with Table 41-1.

CHAPTER 42
PROTECTION AGAINST THERMAL EFFECTS

42-0.1 **Scope**

Persons, fixed equipment, and fixed materials adjacent to electrical equipment shall be protected against harmful effects of heat developed by electrical equipment, or thermal radiation, particularly the following effects:

- combustion or degradation of materials;
- risk of burns;
- impairment of the safe function of installed equipment.

NOTE Protection against overcurrent is dealt with in Chapter 43.

42-1 Protection against fire and harmful thermal effects

42-1.1 Electrical equipment shall not present a fire hazard or harmful effects to adjacent materials. Any relevant manufacturer's erection instructions shall be observed in addition to the requirements of these Electrical Requirements.

42-1.2 Where fixed equipment may attain surface temperatures, which could cause a fire hazard or harmful effects to adjacent materials, the equipment shall either:

- be mounted on or within materials which will withstand such temperatures and are of low thermal conductance, or
- be screened from elements of building construction by materials which will withstand such temperatures and are of low thermal conductance, or
- be mounted to allow safe dissipation of heat at a sufficient distance from any material on which such temperatures could have deleterious thermal effects, any means of support being of low thermal conductance.

42-1.3 Where arcs or sparks may be emitted by permanently connected equipment in normal service, the equipment shall either:

- be totally enclosed in arc-resistant material, or
- be screened by arc-resistant material from building elements on which the arcs could have deleterious thermal effects, or
- be mounted to allow safe extinction of the arc at a sufficient distance from building elements on which the arc could have deleterious thermal effects.

Arc-resistant material used for this protective measure shall be non-combustible, of low thermal conductivity, and of adequate thickness to provide mechanical stability.

42-1.4 Fixed equipment causing a focusing or concentration of heat shall be at a sufficient distance from any fixed object or building element so that the object or element, in normal conditions, cannot be subjected to a dangerous temperature.

42-1.5 Wherever electrical equipment in a single location contains flammable liquid in significant quantity, precautions shall be taken to prevent burning liquid and the products of combustion of the liquid (flame, smoke, toxic gases) spreading to other parts of the building.

NOTE 1 Examples of such precautions are:

- a drainage pit to collect leakages of liquid and ensure their extinction in the event of fire, or
- installation of the equipment in a chamber of adequate fire resistance and the provision of sills or other means of preventing burning liquid spreading to other parts of the building, such a chamber being ventilated solely to the external atmosphere.

NOTE 2 The generally accepted lower limit for a significant quantity is 25 l.

NOTE 3 For less than 25 l, an arrangement to prevent the escape of liquid will suffice.

NOTE 4 It is desirable to switch off supply at the onset of a fire.

42-1.6 The materials of enclosures arranged around electrical equipment during erection shall withstand the highest temperature likely to be produced by the electrical equipment.

Combustible materials are not suitable for the construction of these enclosures unless preventive measures against ignition are taken, such as covering with non-combustible or not readily combustible material of low thermal conductivity.

42-2 Measures for protection against fire

42-2.1 General

The requirements of this statement shall be observed in addition to those of 42-1 for installations in locations where the conditions of external influences described in 42-2.2 exist.

42-2.2 Conditions of evacuation in an emergency

Condition BD2: Low-density occupation, difficult conditions of evacuation

BD3: High-density occupation, easy conditions of evacuation

BD4: High-density occupation, difficult conditions of evacuation

(according to Table 51-1 of Chapter 51).

NOTE Authorities responsible for building construction, public gatherings, fire prevention, etc. may specify which BD condition is applicable.

42-2.2.1 In conditions BD2, BD3 and BD4, wiring systems shall not encroach on escape routes unless the wiring is provided with sheaths or enclosures which, for a duration of not less than 2 hours,

- will not contribute to, or propagate a fire, and
- will not attain a temperature high enough to ignite adjacent material.

NOTE Tests on cables under fire conditions are given in SASO 752, SASO 2294, SASO 2295, SASO 2433, SASO 2434, SASO 2296 and SASO IEC 60332-3-25), Tests on conduit under fire conditions are given in SASO 254.

Wiring systems encroaching on escape routes shall not be within arm's reach unless they are provided with protection against mechanical damage likely to occur during an evacuation. Any wiring systems in escape routes shall be as short as practicable.

42-2.2.2 In conditions BD3 and BD4, switchgear and controlgear devices, except certain devices to facilitate evacuation shall be accessible only to authorized persons. If they are placed in passages, they shall be enclosed in cabinets or boxes constructed of non-combustible or not readily combustible material.

42-2.2.3 In conditions BD3, BD4 and in escape routes, the use of electrical equipment containing flammable liquids is prohibited.

NOTE Individual auxiliary capacitors incorporated in apparatus are not subject to this requirement. This exception principally concerns discharge lamps and capacitors of motor starters.

42-2.3 Nature of processed or stored materials

Condition BE2: Fire risk (according to Table 51-1 of Chapter 51).

NOTE 1 Quantities of flammable materials, surface or volume, of the locations may be regulated by concerned authorities.

NOTE 2 For explosion risks, see SASO IEC 60079-14.

42-2.3.1 Electrical equipment shall be restricted to that necessary to the use of these locations, except wiring systems according to 42-2.3.6.

42-2.3.2 Where it is expected that dust sufficient to cause a fire hazard could accumulate on enclosures of electrical equipment, measures shall be taken to prevent the enclosures from attaining excessive temperatures.

42-2.3.3 Electrical equipment shall be so selected and erected that its normal temperature rise and foreseeable temperature rise during a fault cannot cause a fire.

These arrangements may be effected by the construction of equipment or its conditions of installation.

Special measures are not necessary where the temperature of surfaces is unlikely to cause combustion of nearby substances.

42-2.3.4 Switchgear for protection, control and isolation shall be placed outside locations presenting BE2 conditions, unless it is in an enclosure providing a degree of protection appropriate for such a location but at least IP4X.

42-2.3.5 Where wiring is not embedded in non-combustible material, precautions shall be taken to ensure that the wiring cannot propagate flame.

In particular, cables shall as a minimum, satisfy the test under fire conditions specified in SASO 752.

42-2.3.6 Wiring systems, which traverse these locations, but are not necessary to the use of these locations, shall satisfy the following conditions:

- the wiring systems are made in accordance with the rules of 42-2.3.5;
- they have no connection along the route inside these locations, unless these connections are placed in a fire-resistant enclosure;
- they are protected against overcurrent in accordance with the rules of 42-2.3.11.

42-2.3.7 In forced-air heating installations, the air intake shall be outside locations, where presence of combustible dust exists. The temperature of the outgoing air shall not be such as to cause fire in the location.

42-2.3.8 Motors, other than light-duty servomotors, which are automatically or remotely controlled, or which are not continuously supervised, shall be protected against excessive temperature rise by temperature responsive devices.

42-2.3.9 Luminaires shall be appropriate for condition BE2 and be provided with enclosures providing a degree of protection of at least IP4X.

Lamps and elements of lighting apparatus shall be adequately protected in places where mechanical damage is anticipated, for example, by sufficiently robust plastic covers, grilles or robust glass covers. These protective devices shall not be fixed on lampholders unless the lamp holders are designed for this purpose.

42-2.3.10 Where it is necessary to limit the consequences of fault currents in wiring systems from the point of view of fire risks, the circuit shall either be:

- protected by a residual current protective device, the rated operating residual current of which does not exceed 0.5 A, or
- monitored by a continuous insulation monitoring device which initiates an alarm on the occurrence of an insulation fault.

A bare monitoring conductor, which may be a protective conductor, may be incorporated in the wiring system of the corresponding circuit, unless the wiring system comprises a metallic enclosure connected to the protective conductor.

42-2.3.11 Circuits supplying or traversing locations where condition BE2 applies, shall be protected against overload and against short-circuits by protective devices located on the supply side of these locations.

42-2.3.12 In circuits supplied at safety extra-low voltage (ELV), live parts shall be:

- either contained in enclosures affording the degree of protection IP2X or IPXXB,
- or provided with insulation capable of withstanding a test voltage of 500 V a.c. for 1 min.

regardless of the nominal voltage of the circuit. This is in addition to the requirements of 41-1.1.4.3 of Chapter 41.

42-2.3.13 PEN conductors are not allowed in locations where condition BE2 applies, except for circuits traversing such locations.

42-2.4 Combustible constructional materials

Condition CA2: Combustible materials (according to Table 51-1).

42-2.4.1 Precautions shall be taken to ensure that electrical equipment cannot provoke the ignition of walls, floors and ceilings.

42-2.5 Fire propagating structures

Condition CB2: Propagation of fire (according to Table 51-1).

42-2.5.1 In structures of which the shape and dimensions facilitate the spread of fire, precautions shall be taken to ensure that the electrical installation cannot propagate a fire (e.g. chimney effect).

NOTE Fire detectors may be provided which ensure the implementation of measures for preventing propagation of fire, for example, the closing of fire-proof shutters in ducts, troughs or trunking.

42-3 Protection against burns

Accessible parts of electrical equipment within arm's reach shall not attain a temperature likely to cause burns to persons, and shall comply with the appropriate limit stated in table 42-1. All parts of the installation likely in normal service to attain, even for short periods, temperatures exceeding the limits stated in Table 42-1 shall be guarded so as to prevent any accidental contact.

However, the values in Table 42-1 do not apply to equipment complying with Saudi Standards for the type of equipment concerned.

Table 42-1 Temperature limits in normal service for accessible parts of equipment within arm's reach

Accessible parts	Material of accessible surfaces	Maximum temperatures °C
Hand-held means of operation	Metallic Non-metallic	55 65
Parts intended to be touched but not hand-held	Metallic Non-metallic	70 80
Parts which need not be touched for normal operation	Metallic Non-metallic	80 90

42-4 Protection against overheating

42-4.1 Forced air heating systems

42-4.1.1 Forced air heating systems shall be such that their heating elements, other than those of central storage heaters, cannot be activated until the prescribed air flow has been established and are deactivated when the air flow is reduced or stopped. In addition, they shall have two temperature

limiting devices independent of each other which prevent permissible temperatures from being exceeded in air ducts.

42-4.1.2 The frame and enclosure of heating elements shall be of non-combustible material.

42-4.2 Appliances producing hot water or steam

All appliances producing hot water or steam shall be protected by design or erection against overheating in all service conditions. Unless the appliances comply as a whole with the appropriate Saudi Standards, the protection shall be by means of an appropriate non-self-resetting device, functioning independently of the thermostat.

If an appliance has no free water or steam outlet, it shall also be provided with a device, which limits the water pressure.

CHAPTER 43
PROTECTION AGAINST OVERCURRENT

43-0.1 Scope

This chapter describes how live conductors are protected by one or more devices for automatic interruption of the supply in the event of overload (see 43-3) and short-circuits (see 43-4) except in cases where the overcurrent is limited in accordance with 43-6 or by the conditions described in 43-3.3, 43-3.5 or 43-4.3 are met. Further, protection against overload and against short-circuits shall be coordinated in accordance with 43-5.

NOTE 1 Live conductors protected against overload in accordance with 43-3 are considered to be protected also against faults likely to cause overcurrents of a magnitude similar to overload currents.

NOTE 2 The requirements of this chapter do not take account of external influences. For the application of protective measures in relation to conditions of external influences, see 41-0.3.4 and 42-2.

NOTE 3 Protection of conductors according to this chapter does not necessarily protect the equipment connected to the conductors.

Protective devices shall be provided to break any overcurrent flowing in the circuit conductors before such a current could cause a danger due to thermal and mechanical effects or a temperature rise detrimental to insulation, joints, terminations, or surroundings of the conductors.

43-1 Requirements according to the nature of the circuits

43-1.1 Protection of phase conductors

43-1.1.1 Detection of overcurrent shall be provided for all phase conductors; it shall cause the disconnection of the conductor in which the overcurrent is detected, but not necessarily the disconnection of other live conductors, except where 43-1.1.2 applies.

43-1.1.2 In TT systems, for circuits supplied between phases and in which the neutral conductor is not distributed, overcurrent detection need not be provided for one of the phase conductors, provided that the following conditions are simultaneously fulfilled:

a) there exists, in the same circuit or on the supply side, differential protection intended to cause disconnection of all the phase conductors;

b) the neutral conductor is not distributed from an artificial neutral point of the circuits situated on the load side of the differential protective device mentioned in a).

NOTE If disconnection of a single phase may cause danger, for example in the case of three-phase motors, appropriate precautions should be taken.

43-1.2 Protection of the neutral conductor

43-1.2.1 TT or TN systems

Where the cross-sectional area of the neutral conductor is at least equal or equivalent to that of the phase conductors, it is not necessary to provide overcurrent detection for the neutral conductor or a disconnecting device for that conductor.

Where the cross-sectional area of the neutral conductor is less than that of the phase conductors, it is necessary to provide overcurrent detection for the neutral conductor, appropriate to the cross-sectional area of that conductor; this detection shall cause the disconnection of the phase conductors, but not necessarily of the neutral conductor.

However, overcurrent detection need not be provided for the neutral conductor if the two following conditions are simultaneously fulfilled:

- the neutral conductor is protected against short-circuit by the protective device for the phase conductors of the circuit, and
- the maximum current likely to be carried by the neutral conductor is, in normal service, clearly less than the value of the current-carrying capacity of that conductor.

NOTE This second condition is satisfied if the power carried is shared as evenly as possible between the different phases, for example if the sum of the powers absorbed by current-using equipment supplied from each phase and neutral (such as lighting and socket-outlets) is much less than the total power carried by the circuit concerned. The cross-sectional area of the neutral conductor should be not less than the appropriate value prescribed in Chapter 52.

43-1.2.2 IT systems

In IT systems it is strongly recommended that the neutral conductor should not be distributed.

However, where the neutral conductor is distributed, it is generally necessary to provide overcurrent detection for the neutral conductor of every circuit, which will cause the disconnection of all the live conductors of the corresponding circuit, including the neutral conductor. This measure is not necessary if:

- the particular neutral conductor is effectively protected against short-circuit by a protective device placed on the supply side, for example at the origin of the installation, in accordance with the rules stated in 43-4.5; or if
- the particular circuit is protected by a residual current-operated protective device with a rated residual current not exceeding 0.15 times the current-carrying capacity of the corresponding neutral conductor. This device shall disconnect all the live conductors of the corresponding circuit, including the neutral conductor.

43-1.3 Disconnection and reconnection of the neutral conductor

Where disconnection of the neutral conductor is required, disconnection and reconnection shall be such that the neutral conductor shall not be disconnected before the phase conductors and shall be reconnected at the same time as or before the phase conductors.

43-2 Nature of protective devices

The protective devices shall be of the appropriate types indicated by 43-2.1 to 43-2.3.

43-2.1 Devices ensuring protection against both overload current and short-circuit current

These protective devices shall be capable of breaking any overcurrent up to and including the prospective short-circuit current at the point where the device is installed. They shall satisfy the requirements of 43-3 and 43-4.5.1. Such protective devices may be:

- circuit-breakers incorporating overload release complying with SASO IEC 61009, SASO IEC 60947-1, SASO IEC 60947-2 or SASO 1349;
- circuit-breakers in conjunction with fuses;
- fuses having fuse-links with gG characteristics complying with SASO 1899 and SASO IEC 60269-2 or SASO IEC 60269-3.

NOTE 1 The fuse comprises all the parts that form the complete protective device.

NOTE 2 The use of a protective device having a breaking capacity below the value of the prospective short-circuit current at its place of installation is subject to the requirements of 43-4.5.1.

43-2.2 Devices ensuring protection against overload current only

These are generally inverse-time-lag protective devices whose interrupting capacity may be below the value of the prospective short-circuit current at the point where the devices are installed. They shall satisfy the requirements of 43-3.

43-2.3 Devices ensuring protection against short-circuit current only

These devices shall be installed where overload protection is achieved by other means or where the requirements of 43-3 allow overload protection to be dispensed with. The devices shall be capable of breaking the short-circuit current up to and including the prospective short-circuit current. They shall satisfy the requirements of 43-4.

Such devices may be:

- circuit-breakers with short-circuit release complying with SASO 1349, SASO IEC 60947-1, SASO IEC 60947-2 or SASO IEC 61009,
- fuses complying with SASO 1899 and SASO IEC 60269-2 or SASO IEC 60269-3.

43-3 Protection against overload current

43-3.1 Co-ordination between conductors and overload protective devices

The operating characteristics of a device protecting a cable against overload shall satisfy the two following conditions:

$$I_B \leq I_n \leq I_Z \quad (1)$$

$$I_2 \leq 1.45 \text{ x } I_Z \quad (2)$$

Where:

I_B is the current for which the circuit is designed;

I_Z is the continuous current-carrying capacity of the cable (see 52-3 of Chapter 52);

I_n is the nominal current of the protective device;

NOTE For adjustable protective devices, the nominal current I_n is the current setting selected if the protective device has a restricted access to its adjustable means. Restricted access shall be defined as the following:

- Removable and sealable covers over the adjusting means.
- Bolted equipment enclosure door.
- Locked doors accessible only to qualified personnel.

If the above conditions are not satisfied the nominal current I_n shall be the maximum settings possible.

I_2 is the current ensuring effective operation in the conventional time of the protective device.

The current I_2 ensuring effective operation of the protective device is given in the product standard or may be provided by the manufacturer.

NOTE Protection in accordance with this statement does not ensure complete protection in certain cases, for example against sustained overcurrent less than I_2, nor will it necessarily results in an economical solution. Therefore it is assumed that the circuit is so designed that small overloads of long duration will not frequently occur.

43-3.2 Position of devices for overload protection

43-3.2.1 A device ensuring protection against overload shall be placed at the point where a change, such as a change in cross-sectional area, nature, method of installation or in constitution, causes a reduction in the value of current-carrying capacity of the conductors, except where 43-3.2.2 and 43-3.3 apply.

43-3.2.2 The device protecting the conductor against overload may be placed along the run of that conductor if the part of the run between the point where a change occurs (in cross-sectional area, nature, method of installation or constitution) and the position of the protective device has neither branch-circuits nor socket-outlets and fulfils one of the following two conditions:

a) it is protected against short-circuit current in accordance with the requirements stated in 43-4;

b) its length does not exceed 3 m, it is carried out in such a manner as to reduce the risk of short-circuit to a minimum, and it is not placed near combustible material (see 43-4.2.1).

43-3.3 Omission of devices for protection against overload

The various cases stated in this statement shall not be applied to installations situated in locations presenting a fire risk or risk of explosion and where the requirements for special installations and locations specify different conditions.

Devices for protection against overload need not be provided for:

a) a conductor situated on the load side of a change in cross-sectional area, nature, method of installation or in constitution, which is effectively protected against overload by a protective device placed on the supply side,

b) a conductor which is not likely to carry overload current, provided that this conductor is protected against short-circuit in accordance with the requirements of 43-4 and that it has neither branch circuits nor socket-outlets,

c) installations for telecommunications, control, signalling and the like,

d) distribution circuits comprising cables laid in the earth or overhead lines where overloading of the circuits will not cause danger.

43-3.4 Position or omission of devices for protection against overload in IT systems

43-3.4.1 The provisions in 43-3.2.2 and 43-3.3 for an alternative position or omission of devices for protection against overload are not applicable to IT systems unless each circuit not protected against overload is protected by one of the following means:

a) use of the protective measures described in 41-3.2,

b) protection of each circuit by a residual current protective device which will operate immediately on the second fault,

c) use of an insulation monitoring device which either:

- causes the disconnection of the circuit when the first fault occurs, or
- gives a signal indicating the presence of a fault. The fault shall be rectified according to the operational requirements and recognizing the risk from a second fault.

43-3.4.2 In IT systems without a neutral conductor the overload protective device may be omitted in one of the phase conductors if a residual current protective device is installed in each circuit.

43-3.5 Cases where omission of devices for overload protection is recommended for safety reasons

The omission of devices for protection against overload is recommended for circuits supplying current-using equipment where unexpected opening of the circuit could cause danger.

Examples of such cases are:

- exciter circuits of rotating machines,
- supply circuits of lifting magnets,
- secondary circuits of current transformers.
- supply circuits of fire extinguishing equipment.

NOTE In such cases consideration should be given to the provision of an overload alarm.

43-3.6 Overload protection of conductors in parallel

Where a single protective device protects several conductors in parallel there shall be no branch circuits or devices for isolation or switching in the parallel conductors.

This statement does not preclude the use of ring circuits.

43-3.6.1 Equal current sharing between parallel conductors

Where a single device protects conductors in parallel sharing currents equally, the value of I_Z to be used in 43-3.1 is the sum of the current-carrying capacities of the various conductors.

It is deemed that current sharing is equal if the requirements of the first indent of 52-3.7 a) are satisfied.

43-3.6.2 Unequal current sharing between parallel conductors

Where the use of a single conductor, per phase, is impractical and the currents in the parallel conductors are unequal, the design current and requirements for overload protection for each conductor shall be considered individually.

NOTE Currents in parallel conductors are considered to be unequal if the difference between any currents is more than 10 % of the design current for each conductor. Guidance is given in Annex A.43 (see A.43.2).

43-4 Protection against short-circuit currents

43-4.1 Determination of prospective short-circuit currents

The prospective short-circuit current at every relevant point of the installation shall be determined. This may be done either by calculation or by measurement.

43-4.2 Position of devices for short-circuit protection

A device ensuring protection against short-circuit shall be placed at the point where a reduction in the cross-sectional area of the conductors or another change causes a change to the current-carrying capacity of the conductors, except where 43-4.2.1, 43-4.2.2 or 43-4.3 apply.

43-4.2.1 The device for protection against short-circuit may be placed other than as specified in 43-4.2, under the following conditions.

The part of the conductor between the point of reduction of cross-sectional area or other change and the position of the protective device shall

a) not exceed 3 m in length,

b) be installed in such a manner as to reduce the risk of a short-circuit to a minimum,

NOTE This condition may be obtained for example by reinforcing the protection of the wiring against external influences.

c) not be placed close to combustible material.

43-4.2.2 A protective device may be placed on the supply side of the reduced cross-sectional area or another change made, provided that it possesses an operating characteristic such that it protects the wiring situated on the load side against short-circuit, in accordance with the rule of 43-4.5.2.

43-4.3 Omission of devices for short-circuit protection

Devices for protection against short-circuit need not be provided for:

- conductors connecting generators, transformers, rectifiers, accumulator batteries to the associated control panels, the protective devices being placed on these panels,
- circuits where disconnection could cause danger for the operation of the installations concerned, such as those quoted in 43-3.5,
- certain measuring circuits,

Provided that, the two following conditions are simultaneously fulfilled:

a) the wiring is carried out in such a way as to reduce the risk of a short-circuit to a minimum (see item b) of 43-4.2.1);

b) the wiring shall not be placed close to combustible material.

43-4.4 Short-circuit protection of conductors in parallel

A single protective device may protect conductors in parallel against the effects of short-circuit provided that the operating characteristic of that device ensures its effective operation should a fault occur at the most onerous position in one parallel conductor. Account shall be taken of the sharing of the short-circuit currents between the parallel conductors. A fault can be fed from both ends of a parallel conductor.

If operation of a single protective device may not be effective, then one or more of the following measures shall be taken.

a) A single protective device may be used provided that:

- the wiring is carried out in such a way as to reduce the risk of a short-circuit in any parallel conductor to a minimum, for example by protection against mechanical damage, and
- conductors are not placed close to combustible material.

b) For two conductors in parallel a short-circuit protective device is provided at the supply end of each parallel conductor.

c) For more than two conductors in parallel short-circuit protective devices are provided at the supply and load ends of each parallel conductor.

Guidance is given in Annex A.43 (see A.43-3).

43-4.5 Characteristics of short-circuit protective devices

Each short-circuit protective device shall meet both of the following conditions:

43-4.5.1 The breaking capacity shall be not less than the prospective short-circuit current at the place of its installation, except where the following paragraph applies.

A lower breaking capacity is admitted if another protective device having the necessary breaking capacity is installed on the supply side. In that case, the characteristics of the devices must be coordinated so that the energy let through by these two devices does not exceed that which can be withstood without damage by the device on the load side and the conductors protected by these devices.

NOTE In certain cases other characteristics may need to be taken into account such as dynamic stresses and arcing energy, for the device on the load side. Details of the characteristics needing co-ordination should be obtained from the manufacturers of the devices concerned.

43-4.5.2 All current caused by a short-circuit occurring at any point of the circuit shall be interrupted in a time not exceeding that which brings the conductors to the admissible limit temperature. For short-circuits of

duration up to 5 s, the time *t*, in which a given short-circuit current will raise the conductors from the highest admissible temperature in normal duty to the limit temperature can, as an approximation, be calculated from the formula:

$$\sqrt{t} = k \times \frac{S}{I}$$

Where:

t is the duration, in seconds;

S is the cross-sectional area, in square millimetres;

I is the effective short-circuit current, in amperes, expressed as r.m.s.value;

k is a factor taking account of the resistivity, temperature coefficient and heat capacity of the conductor material, and the appropriate initial and final temperatures. For common conductor insulation, the values of *k* for phase conductors are shown in Table 43-1.

For very short durations (<0.1 s) where asymmetry of the current is of importance and for current limiting devices k^2S^2 shall be greater than the value of the let-through energy (I^2t) quoted by the manufacture of the protective device.

Table 43-1 Values of *k* for phase conductor

	Conductor insulation					
	PVC ≤ 300 mm^2	PVC >300 mm^2	EPR XLPE	Rubber 60 °C	Mineral	
					PVC	Bare
Initial temperature °C	70	70	90	60	70	105
Final temperature °C	160	140	250	200	160	250
Material of conductor:						
Copper	115	103	143	141	115	135/115[a]
Aluminium	76	68	94	93	–	–
Tin-soldered joints in copper conductors	115	–	–	–	–	–

[a] This value shall be used for bare cables exposed to touch.

NOTE 1 The nominal current of the short-circuit protective device may be greater than the current-carrying capacity of the cable.

NOTE 2 The above factors are based on SASO IEC 60724.

43-5 Co-ordination of overload and short-circuit protection

43-5.1 Protection afforded by one device

Where an overload protective device complies with 43-3 and has a breaking capacity not less than the value of the prospective short-circuit current at its point of installation, it is considered to protect the conductor on the load side of that point also against short-circuit current.

NOTE This assumption may not be valid for the whole range of short-circuit current; its validity should be checked according to the requirements of 43-4.5.

43-5.2 Protection afforded by separate devices

The requirements of 43-3 and 43-4 apply, respectively, to the overload protective device and the short-circuit protective device.

The characteristics of the devices must be co-ordinated so that the energy let through by the short-circuit protective device does not exceed that which can be withstood without damage by the overload protective device.

NOTE This requirement does not exclude the type of coordination specified in SASO IEC 60947-4-1.

43-6 Limitation of overcurrent by characteristics of supply

Conductors are considered to be protected against overload and short-circuit currents where they are supplied from a source incapable of supplying a current exceeding the current-carrying capacity of the conductors (e.g. certain bell transformers, certain welding transformers and certain types of thermoelectric generating sets).

43-7 Discrimination between overcurrent protective devices

In order to avoid unnecessary interruption of supplies, the characteristics and selection of overload protective devices must be such that proper discrimination in their operation is attained. The discrimination is the coordination of automatic protective devices in such a manner that a fault appearing at a given point in a network is cleared by only the protective device installed immediately upstream of the fault.

Annex A.43
(informative)

PROTECTION OF CONDUCTORS IN PARALLEL AGAINST OVERCURRENT

A.43-1 Introduction

Overcurrent protection for conductors connected in parallel should provide adequate protection for all of the parallel conductors. For two conductors of the same cross-sectional area, length and disposition arranged to carry substantially equal currents the requirements for overcurrent protection are straightforward. For more complex conductor arrangements detailed considerations should be given to unequal current sharing between conductors and multiple fault current paths. This annex gives guidance on the necessary considerations.

A.43-2 Overload protection of conductors in parallel

When an overload occurs in a circuit containing parallel conductors, the current in each conductor will increase by the same proportion. Provided that the current is shared equally between the parallel conductors, a single protective device can be used to protect all the conductors. The current-carrying capacity (I_Z) of the parallel conductors is the sum of the current-carrying capacity of each conductor, with the appropriate grouping and other factors applied.

The current sharing between parallel cables is a function of the impedance of the cables. For large single-core cables the reactive component of the impedance is greater than the resistive component and will have a significant effect on the current sharing. The reactive component is influenced by the relative physical position of each cable. If, for example, a circuit consists of two large cables per phase, having the same length, construction and cross-sectional area and arranged in parallel with unfavourable relative position (i.e. cables of the same phase bunched together) the current sharing may be 70 %/30 % rather than 50 %/50 %.

Where the difference in impedance between parallel conductors causes unequal current sharing, for example greater than 10 % difference, the design current and requirements for overload protection for each conductor should be considered individually.

The design current for each conductor can be calculated from the total load and the impedance of each conductor.

For a total of m conductors in parallel, the design current I_{Bk} for conductor k is given by:

$$I_{Bk} = \frac{I_B}{\left(\frac{Z_k}{Z_1} + \frac{Z_k}{Z_2} + \cdots + \frac{Z_k}{Z_{k-1}} + \frac{Z_k}{Z_k} + \frac{Z_k}{Z_{k+1}} + \cdots + \frac{Z_k}{Z_m}\right)}$$

Where:

I_B is the current for which the circuit is designed;

I_{Bk} is the design current for conductor k;

Z_k is the impedance of conductor k;

Z_1 and Z_m are the impedances of conductors 1 and m respectively.

In the case of single-core cables, the impedance is a function of the relative positions of the cables as well as the design of the cable, for example

armoured or unarmoured. It is recommended that current sharing between parallel cables is verified by measurement.

The design current I_{Bk} is used in place of I_B for equation (1) of 43-3.1 as follows:

$$I_{Bk} \le I_n \le I_{zk}$$

The value used for I_Z in 43-3.1, equations (1) and (2), is either

- the continuous current-carrying capacity of each conductor, I_{zk}, if an overload protective device is provided for each conductor (see Figure A.43-1) hence:

$$I_{Bk} \le I_{nk} \le I_{zk}$$

or

- the sum of the current-carrying capacities of all the conductors, ΣI_{zk}, if a single overload protective device is provided for the conductors in parallel (see Figure A.43-2) hence:

$$I_B \le I_n \le \quad I_{zk}$$

Where:

I_{nk} is the nominal current of the protective device for conductor k;

I_{zk} is the continuous current-carrying capacity of conductor k;

I_n is the nominal current of the protective device;

I_{zk} is the sum of the continuous current-carrying capacities of the m conductors in parallel.

NOTE For busbar systems, information should be obtained either from the manufacturer or from SASO 1609 and SASO 1610.

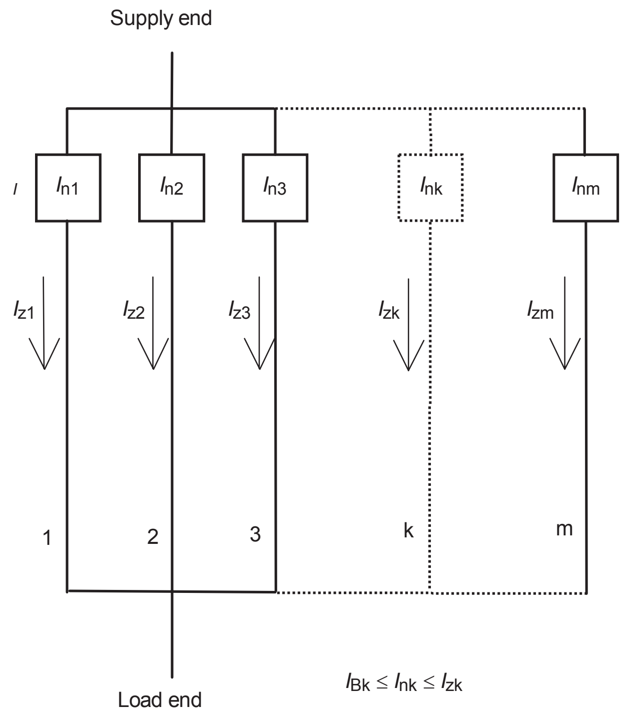


Figure A.43-1 Circuit in which an overload protective device is provided for each of the m conductors in parallel

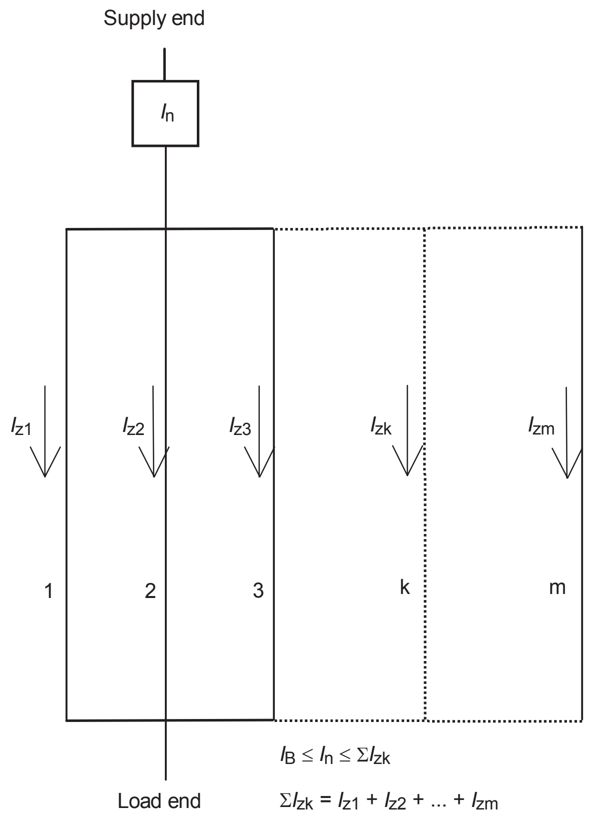


Figure A.43-2 Circuit in which a single overload protective device is provided for the m conductors in parallel

A.43.3 Short-circuit protection of conductors in parallel

When conductors are connected in parallel, the possibility of a short-circuit within the parallel section should be considered.

If two conductors are connected in parallel and the operation of a single protective device may not be effective, then each conductor should have individual protection.

Where three or more conductors are connected in parallel then multiple fault current paths can occur and it may be necessary to provide short-circuit protection at both the supply and load end of each parallel conductor. This situation is illustrated in Figures A.43-3 and A.43-4.

Figure A.43-3 shows that, if a fault occurs in parallel conductor c at point x, the fault current will flow in conductors a, b and c. The magnitude of the fault current and the proportion of the fault current which flows through protective devices cs and cl will depend on the location of the fault. In this example it has been assumed that the highest proportion of the fault current will flow through protective device cs. Figure A.43-4 shows that, once cs has operated, current will still flow to the fault at x via conductors a and b. Because conductors a and b are in parallel, the current through protective devices as and bs may not be sufficient for them to operate in the required time. If this is the case, the protective device cl is necessary. It should be noted that the current flowing through cl will be less than the current which caused cs to operate. If the fault was close enough to cl then cl would operate first. The same situation would exist if a fault occurred in conductors a or b, hence the protective devices al and bl will be required.

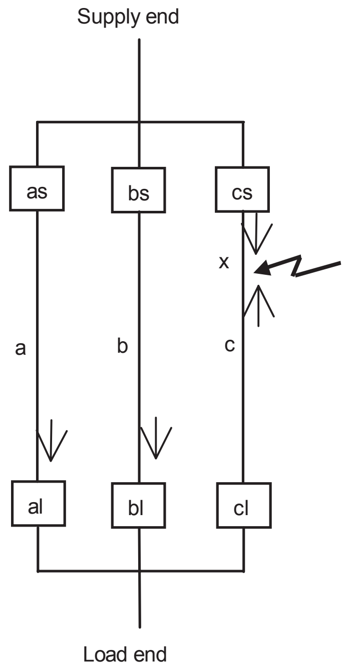


Figure A.43-3 Current flow at the beginning of the fault

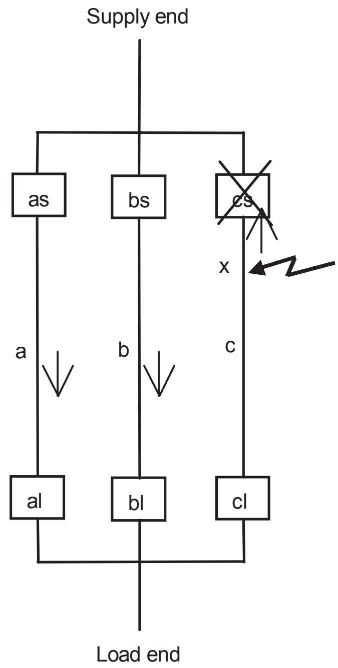


Figure A.43-4 Current flow after operation of the protective device cs

An alternative to the six protective devices would provide a linked protective device at the supply end. The use of a linked protective device has two advantages. Firstly, if a fault at x is cleared by the operation of cs and cl then the circuit will continue to operate with the load being carried by conductors a and b. Hence the fault and subsequent overloading of a and b may not be detected. Secondly, the fault at x may burn open-circuit at the cl side leaving one side of the fault live and undetected.

CHAPTER 44

PROTECTION AGAINST VOLTAGE DISTURBANCES AND ELECTROMAGNETIC DISTURBANCES

44-0.1 Scope

This chapter provides rules for the protection against the effects of conducted and radiated disturbances on electrical installations.

The rules of 42-2 are intended to provide for the safety of persons and equipment in a LV system in the event of a fault between the HV system and earth in the HV part of transformer stations, which supply low-voltage systems. Those rules also describe the means by which transient voltages can be limited to reduce the risk to an acceptable level of failure in the installation, and in electrical equipment connected to it. In this chapter, basic recommendations are described to mitigate electromagnetic disturbances. Actually electromagnetic interferences (EMI) can disturb or damage information technology systems or equipment, equipment with electronic components or circuits.

The rules of this Chapter will not apply to systems, which are wholly or partly under control of public electricity utilities (see scope in Chapter 11).

44-2 Protection of low-voltage installations against temporary overvoltages and faults between high-voltage systems and earth

44-2.1 General requirements

NOTE The following statements consider only four situations, which generally cause the most severe temporary overvoltages, fault between the high-voltage system(s) and earth. The corresponding statements should be read in conjunction with Annex A.44:

- loss of the neutral in a low-voltage TN and TT system (see 44-2.5);
- accidental earthing of a low-voltage IT system (see 44-2.6);
- short-circuit in the low-voltage installation (see 44-2.7).

44-2.1.2 Fault-voltage

The magnitude and the duration of the fault-voltage or the touch voltage due to an earth-fault in the high-voltage system shall not exceed the values given by curve F and T respectively of Figure 44-1.

44-2.1.3 Stress-voltage

The magnitude and the duration of the power-frequency stress voltage of the LV equipment in the consumer's installation due to an earth fault in the high voltage system shall not exceed the values of Table 44-1.

NOTE 1 The power-frequency stress voltage is the voltage, which appears across the insulation.

NOTE 2 A higher stress voltage is permitted for the low-voltage equipment of the sub-station if the insulation level of the equipment is compatible and under the conditions of 44-2.3.

Table 44-1 Permissible stress voltage

Permissible a.c. stress voltage on equipment in low-voltage installations V	Disconnecting time s
U_0 + 250 V	>5
U_0 + 1 200 V	≤5

NOTE 1 In particular cases (e.g. line conductor earthed), where the (highest) nominal voltage of the low-voltage system to earth is not U_0, this voltage shall be specified.

NOTE 2 The first line of the table relates to systems having long disconnection times, for example inductively earthed high-voltage system. The second line relates to systems having short disconnection times, for example solidly earthed high-voltage systems. Both lines together are relevant design criteria for insulation of low-voltage equipment with regard to temporary overvoltage (see SASO IEC 60664-1).

NOTE 3 Such temporary a.c. overvoltage, is also to be expected in basic, double and reinforced insulation of low-voltage equipment used outside the main equipotential bonding and connected to a TN system (whose neutral conductor is earthed in the transformer substation through the protective earth electrode of the high-voltage system). It is not necessary to expect such overvoltage within the area of main equipotential bonding, which is connected to the protective conductor of a TN system at the origin of the installation of the building.

44-2.2 Earthing systems in transformer sub-stations

At the transformer sub-station, there shall be one earthing system to which shall be connected:

- earth electrodes,
- the transformer tank,
- metallic coverings of high-voltage cables,
- metallic coverings of low-voltages cables except where the neutral conductor is earthed via a separate earth electrode,
- earth wires of high-voltage systems,
- the exposed-conductive-parts of high-voltage and low-voltage equipment,
- extraneous-conductive-parts.

44-2.3 Earthing arrangements in transformer sub-stations

The conditions enumerated under 44-2.4 and are deemed to be complied with if one or both of the conditions stated in 44-2.3.1 or the condition in 44-2.3.2 is met. Where none of the conditions of 44-2.3.1 or 44-2.3.2 is met, the requirements of 44-2.4 shall be applied.

44-2.3.1 The transformer sub-stations shall be connected to cables with suitable earthed metallic coverings, whether high-voltage cables, low-voltage cables or a combination of both high- and low-voltage cables.

The total length of these cables shall exceed 1 km.

44-2.3.2 The earthing resistance of the exposed-conductive-parts of the transformer sub-station shall not exceed 1 Ω.

44-2.4 Earthing arrangements with regard to type of earthing systems in LV installations

44-2.4.1 Symbols

In the following statements, the symbols are:

I_m that part of the earth fault current in the high-voltage system that flows through the earth electrode of the exposed-conductive-parts of the transformer sub-station.

R is the resistance of the earth electrode of the exposed-conductive-parts of the transformer sub-station.

R_A is the resistance of the earth electrode of the exposed-conductive-parts of the low voltage equipment.

U_0 is the line-to-neutral voltage of the low-voltage system.

U is the line-to-line voltage of the low-voltage system.

U_f is the fault-voltage in the LV system between exposed-conductive-parts and earth.

U_1 is the stress-voltage in the LV equipment of the transformer sub-station.

U_2 is the stress-voltage in the LV equipment of the consumer's system.

U_L is conventional touch voltage limit.

44-2.4.2 TN systems

a) When the fault-voltage R x I_m is disconnected within a time given in Figure 44-1, the neutral conductor of the LV system may be connected to the earthing electrode of the exposed-conductive-parts of the transformer sub-station (see TN-a in Figure 44-2).

NOTE If the exposed-conductive-parts of the low-voltage equipment of the consumer’s installation within the building are connected to the main equipotential bonding by a protective conductor, the touch voltage will be effectively zero.

b) If the condition under a) is not fulfilled, the neutral conductor of the LV system shall be earthed via an electrically independent earth electrode (see TN-b in Figure 44-2).

44-2.4.3 TT systems

a) When the relation between the stress-voltage (R x I_m + U_0) and the disconnecting time given in Table 44-1 is complied with for the LV equipment of the consumer's installation, the neutral conductor of the LV system may be connected to the earthing electrode of the exposed-conductive-parts of the transformer sub-station (see TT-a in Figure 44-3).

b) If the condition under a) is not fulfilled, the neutral conductor of the LV system shall be earthed via an electrically independent earth electrode (see TT-b in Figure 44-3).

If the exposed-conductive-parts of the low-voltage equipment of the consumer’s installation within the building are connected to the main equipotential bonding by a protective conductor, the touch voltage will be effectively zero.

44-2.4.4 IT systems

a) When the fault-voltage R x I_m is disconnected within a time given in Figure 44-1, the exposed-conductive-parts of the LV equipment of the consumer's installation may be connected to the earthing electrode of the exposed-conductive-parts of the sub-station (see Figures 44-4, 44-9 and 44-10).

If this condition is not fulfilled, the exposed-conductive-parts of the LV equipment of the LV installation shall be connected to an earthing system electrically independent from the earthing electrode of the exposed-conductive-parts of the sub-station (see Figures 44-5 to 44-8).

b) When the exposed-conductive-parts of the LV equipment in the consumer's installation are earthed via an earth electrode electrically independent of the earth electrode of the transformer sub-station, and when the relation between the stress-voltage (R x I_m + U) and the disconnecting time given in Table 44-1 is complied with for the LV equipment of the consumer's installation, the neutral impedance of the LV system, if any, may be connected to the earth electrode of the exposed-conductive-parts of the transformer sub-station (see Figure 44-5).

If this condition is not fulfilled, the neutral impedance shall be earthed via an electrically independent earth electrode (see Figures 44-6 and 44-7).

44-2.5 Stress voltage in case of loss of the neutral conductor in a TN and TT system

Consideration shall be given to the fact that, if the neutral conductor in a three-phase TN or TT system is interrupted, basic, double and reinforced insulation as well as components rated for the voltage between line and neutral conductors can be temporarily stressed with the line-to-line voltage. The stress voltage can reach up to $U = \sqrt{3}\ U_0$.

44-2.6 Stress voltage in case of accidental earthing of an IT system

Consideration shall be given to the fact that, if a line conductor of an IT system is earthed accidentally, basic, double and reinforced insulation rated for the voltage between line and neutral conductors as well as components can be temporarily stressed with the line-to-line voltage. The stress voltage can reach up to $U = \sqrt{3}\ U_0$.

44-2.7 Stress voltage in case of a short-circuit between a line conductor and the neutral conductor

Consideration shall be given to the case of a short-circuit between a phase conductor and the neutral conductor where the stress can reach the value of 1.45 U_0 for a time up to 5 s.

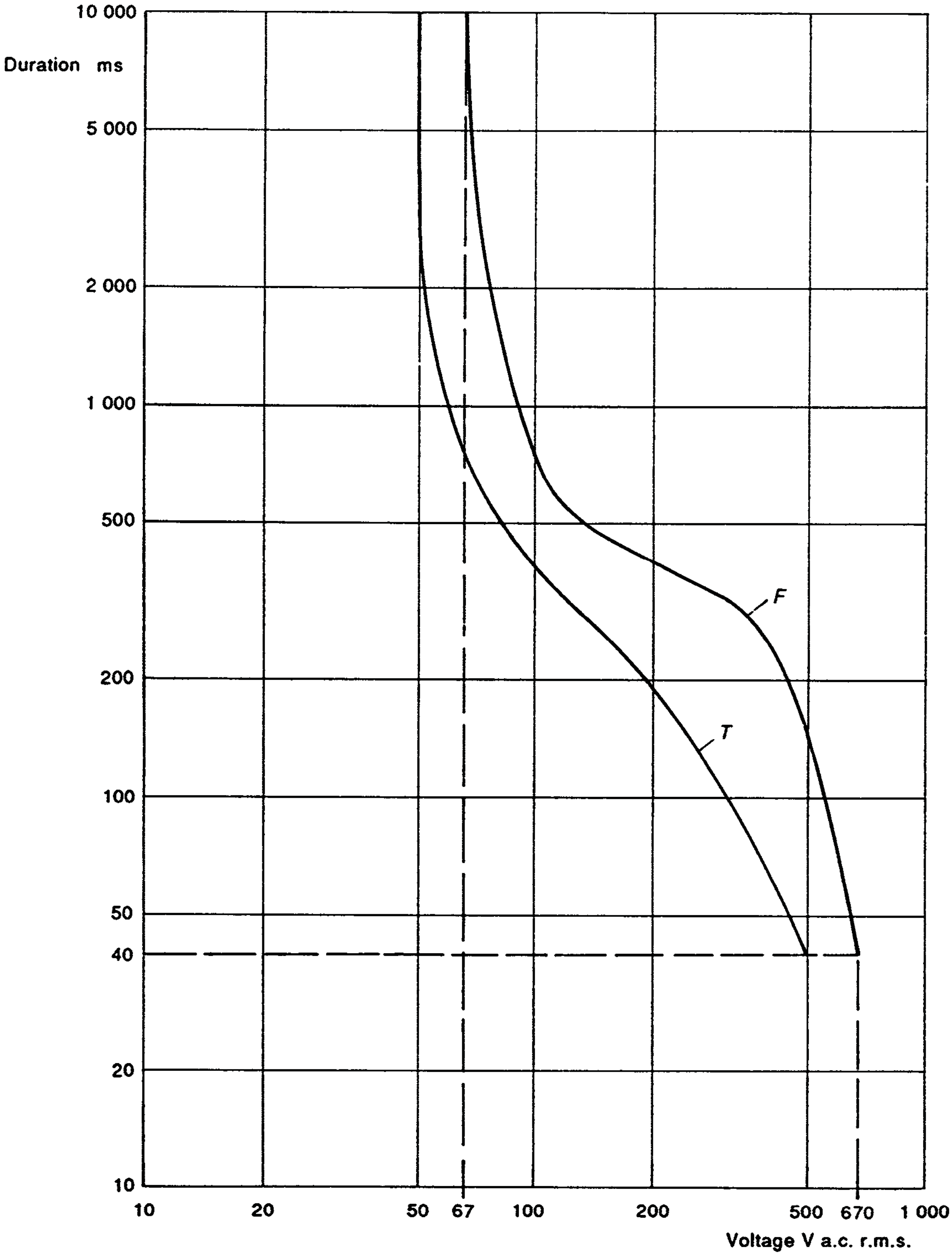


Figure 44-1 Maximum duration of fault-voltage *F* and touch voltage *T* due to an earth-fault in the HV system

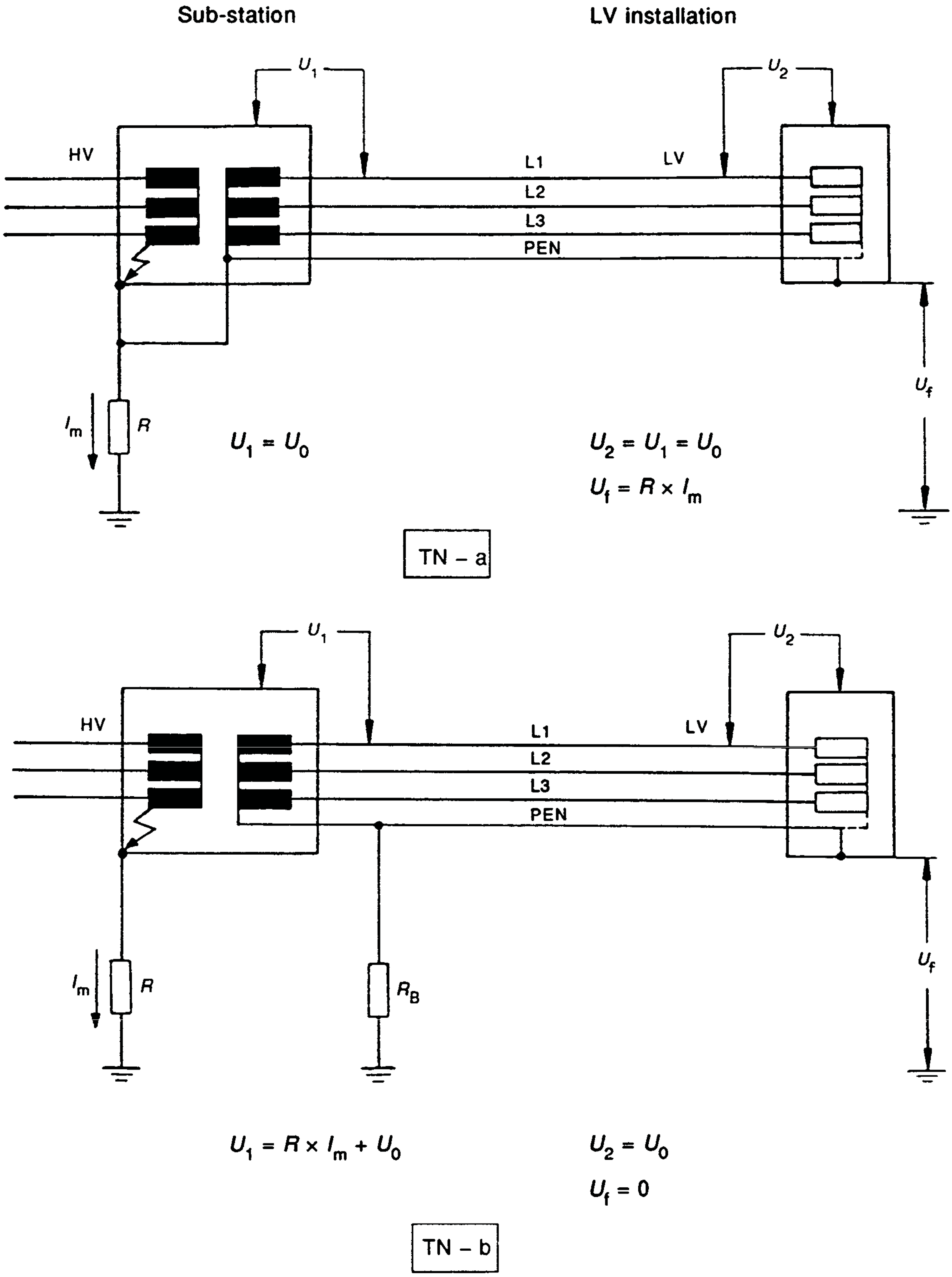


Figure 44-2 TN systems

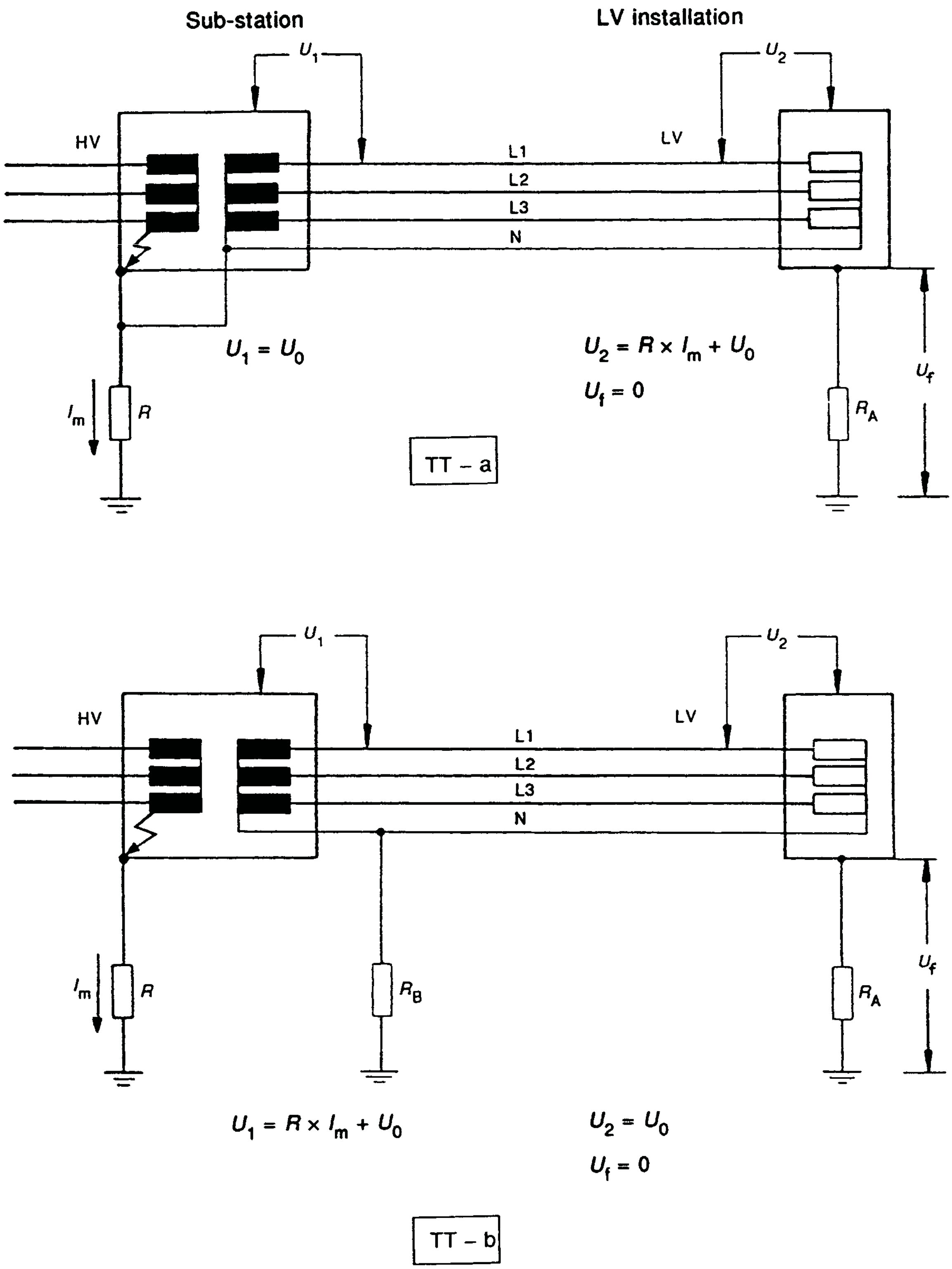
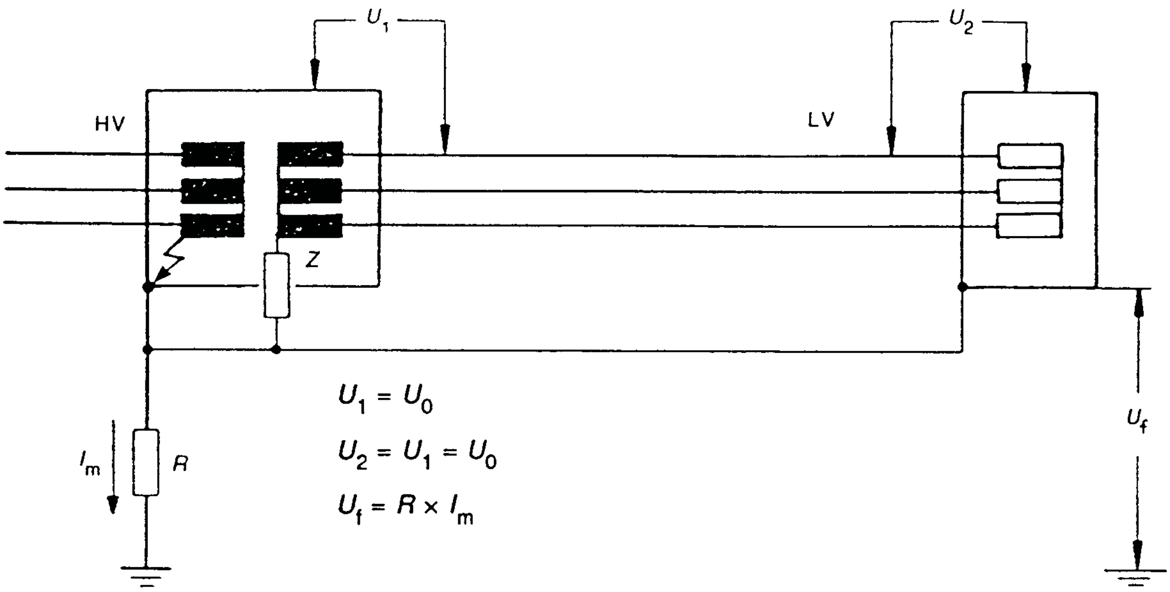
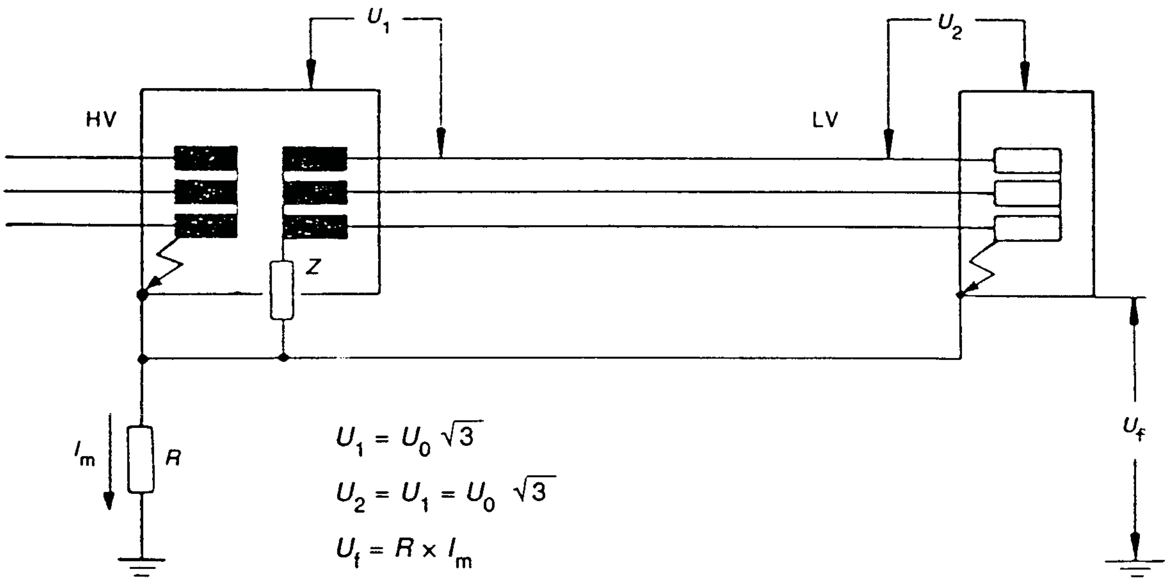


Figure 44-3 TT systems

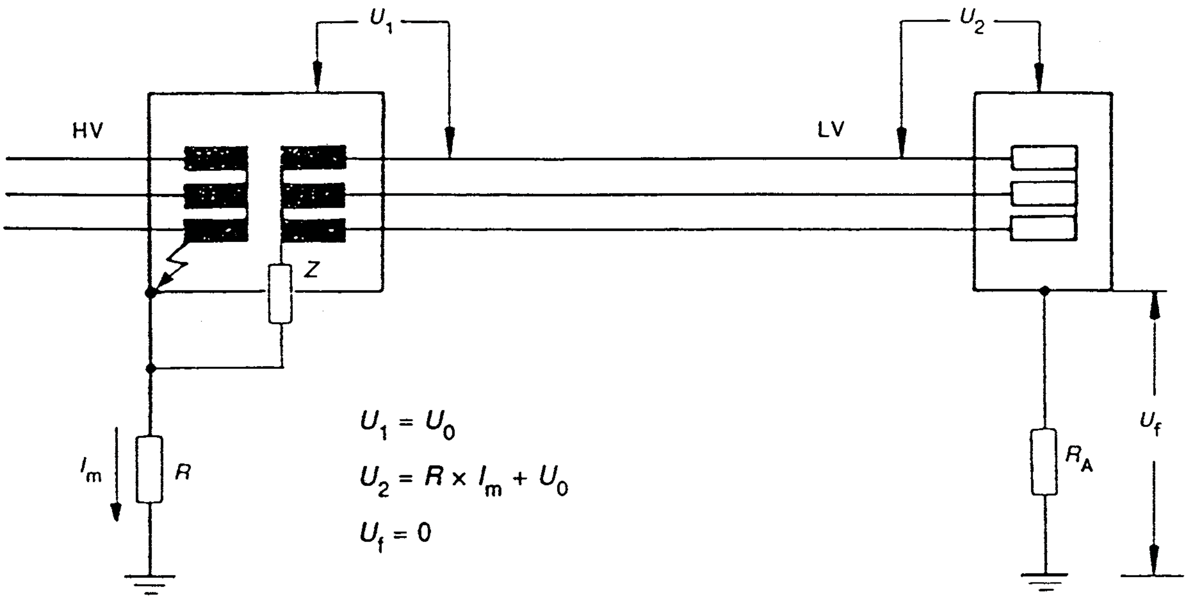


1. No fault exists in the LV system

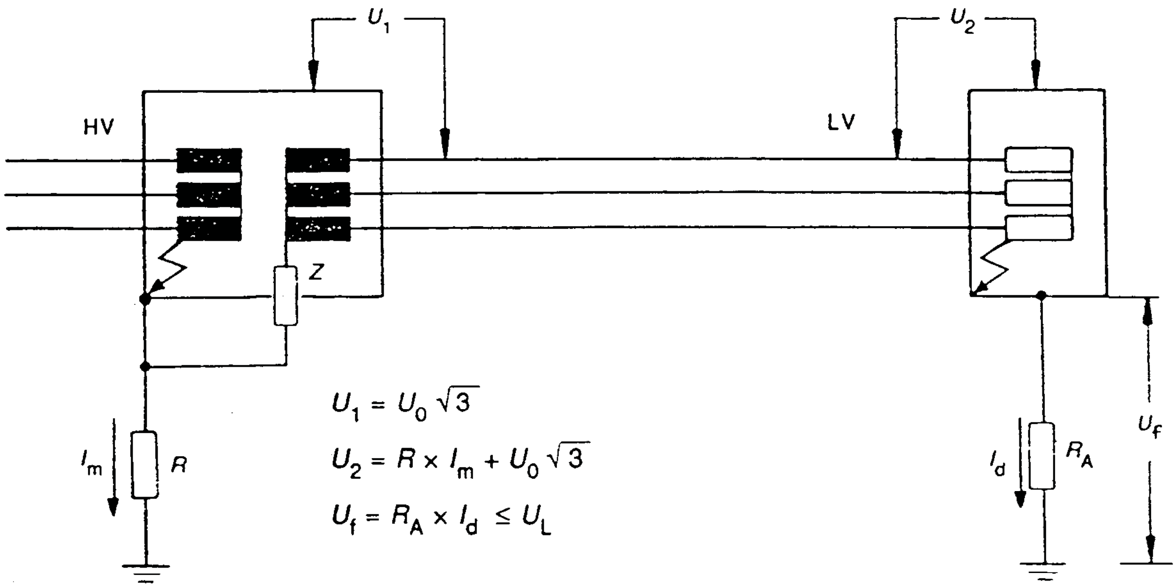


2. A first fault exists in the LV system

Figure 44-4 IT system, example a

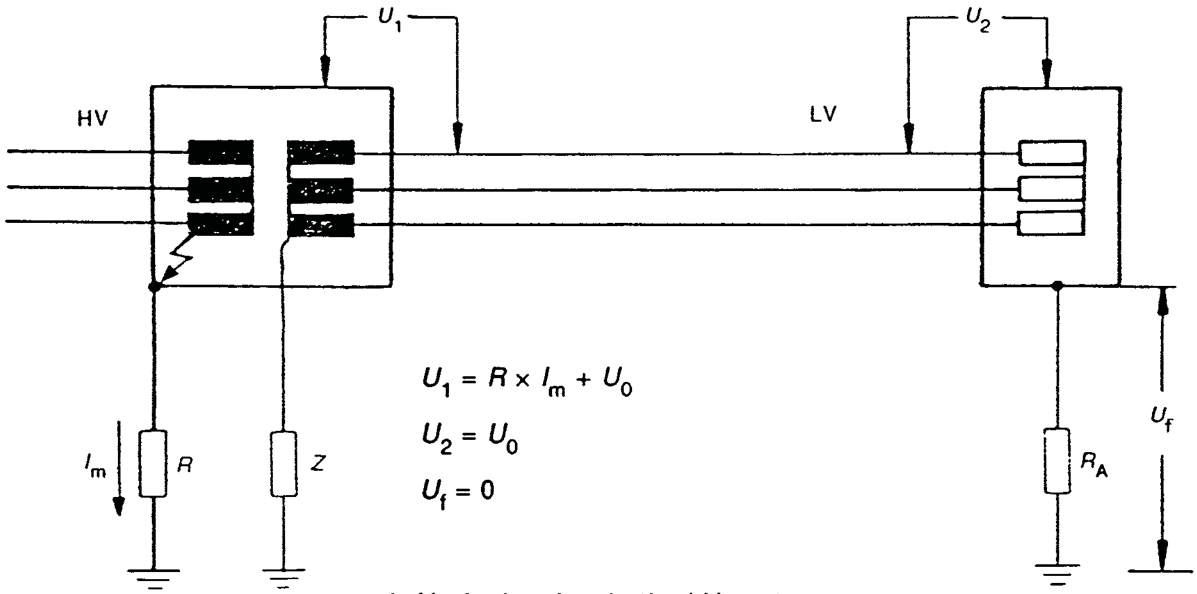


1. No fault exists in the LV system

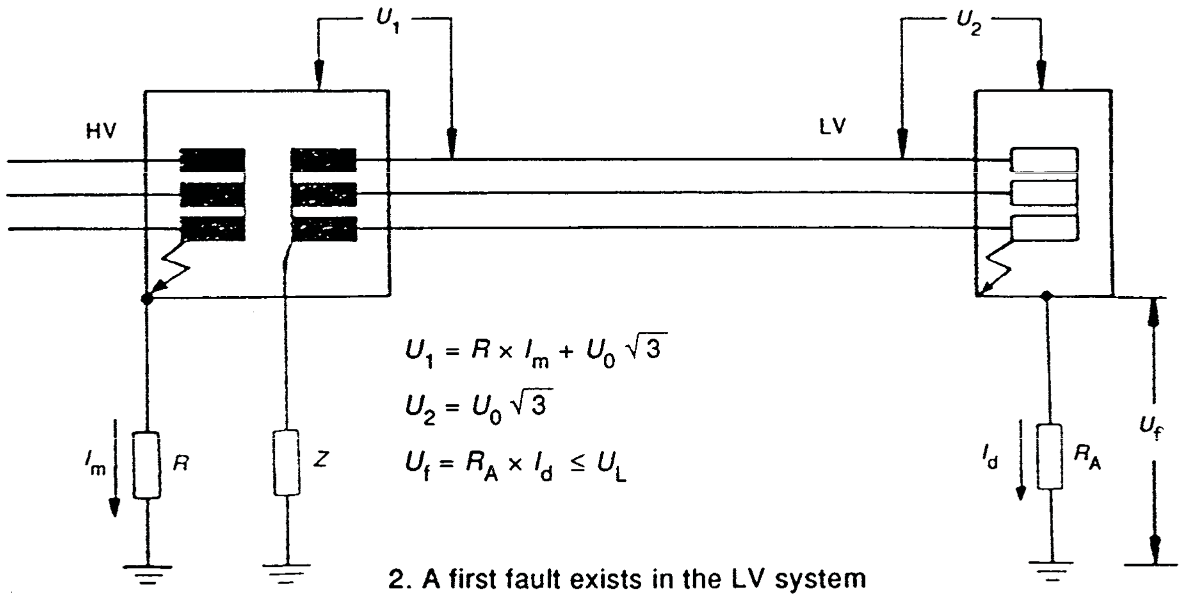


2. A first fault exists in the LV system

Figure 44-5 IT system, example b

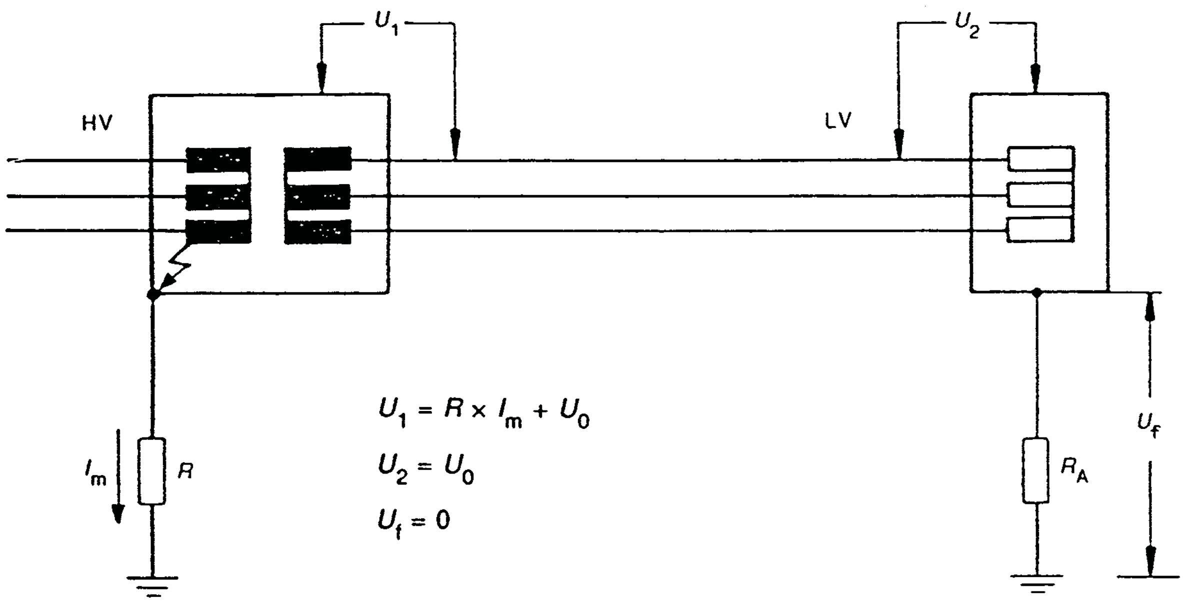


1. No fault exists in the LV system

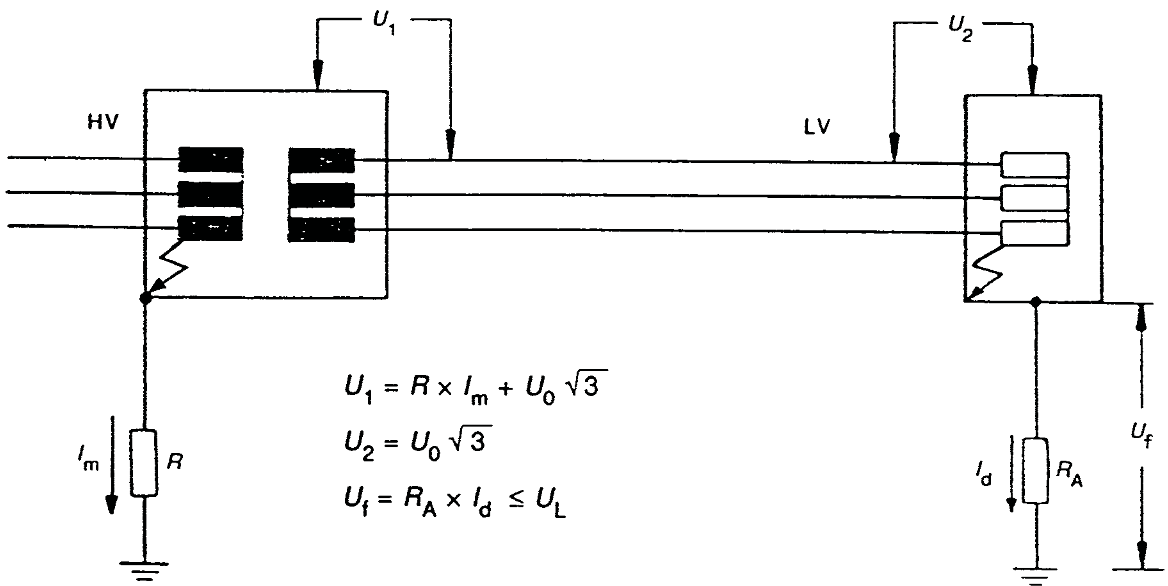


2. A first fault exists in the LV system

Figure 44-6 IT system, example c1

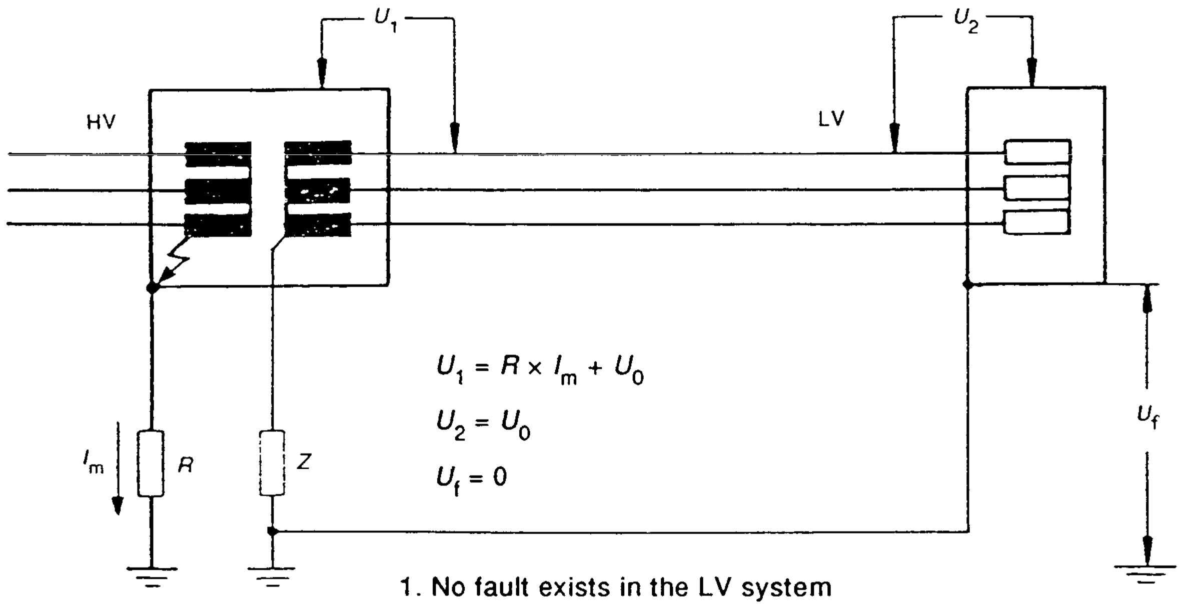


1. No fault exists in the LV system

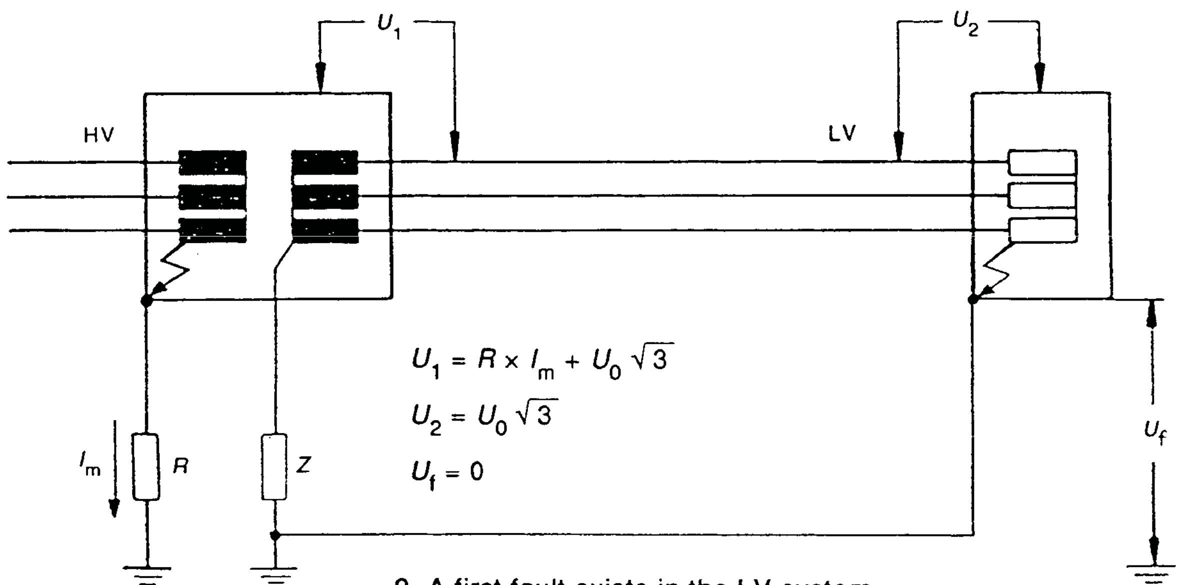


2. A first fault exists in the LV system

Figure 44-7 IT system, example c2



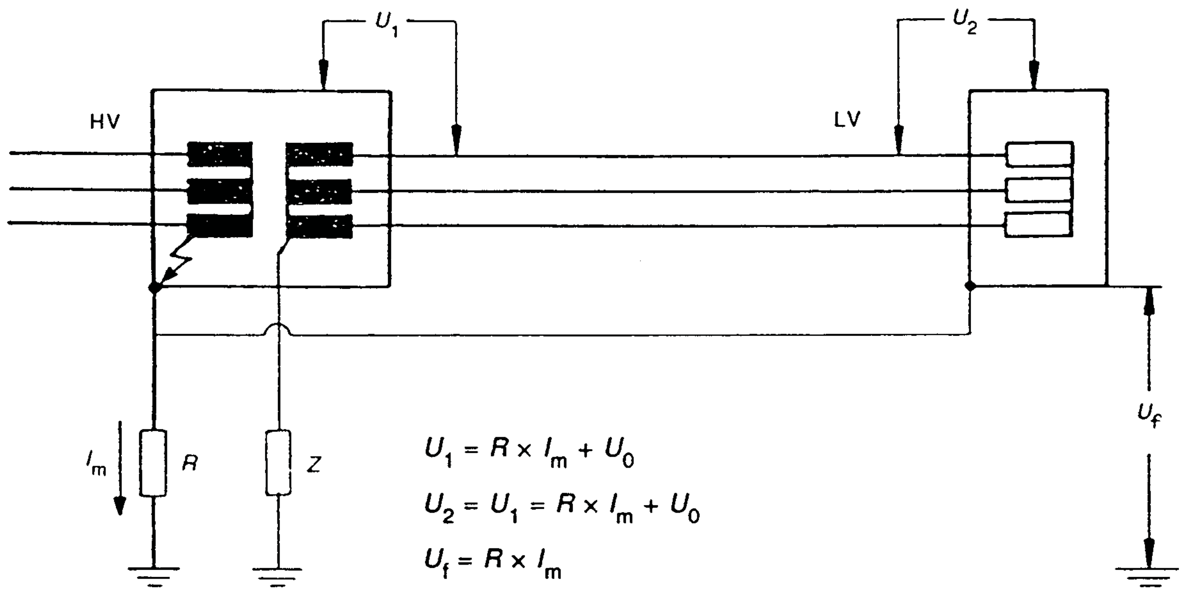
1. No fault exists in the LV system



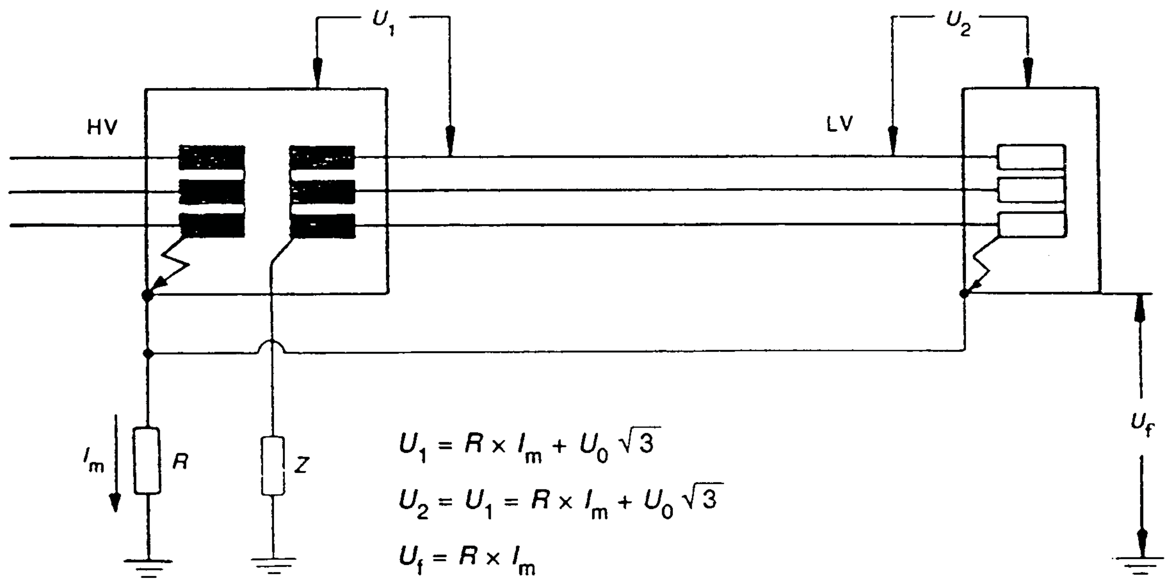
2. A first fault exists in the LV system

Figure 44-8 IT system, example d

]

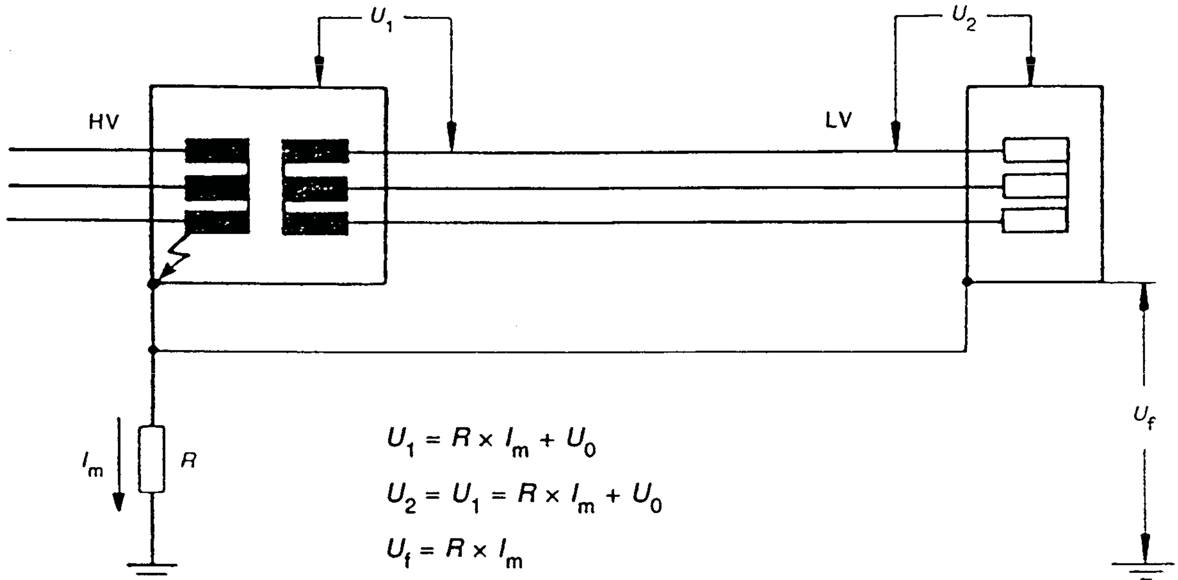


1. No fault exists in the LV system

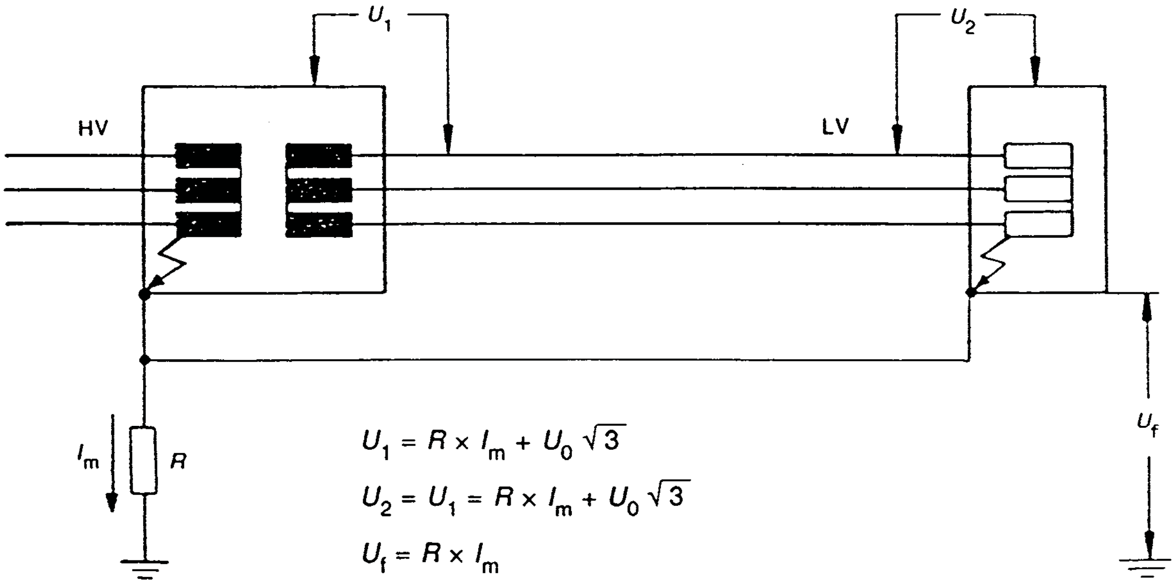


2. A first fault exists in the LV system

Figure 44-9 IT system, example e1



1. No fault exists in the LV system



2. A first fault exists in the LV system

Figure 44-10 IT system, example e2

44-3 Protection against overvoltages of atmospheric origin or due to switching

44-3.1 General

This division deals with protection of electrical installations against transient overvoltages of atmospheric origin transmitted by the supply distribution system and against switching overvoltages.

In general, switching overvoltages are lower than overvoltages of atmospheric origin and therefore the requirements regarding protection against overvoltages of atmospheric origin normally cover protection against switching overvoltages.

NOTE 1 Statistical evaluation of measurements have shown that there is a low risk of switching overvoltages higher than the level of overvoltage category ll See 44-3.2.

Consideration shall be given to the overvoltages which can appear at the origin of an installation, to the expected keraunic level (Lightning Prevalence) and to the location and characteristics of surge protective devices, so that the probability of incidents due to overvoltage stresses is reduced to an acceptable level for the safety of persons and property, as well as for the continuity of service desired.

The values of transient overvoltages depend on the nature of the supply distribution system (underground or overhead) and the possible existence of a surge protective device upstream of the origin of the installation and the voltage level of the supply system.

This division provides guidance where protection against overvoltages is covered by inherent control or assured by protective control. If the protection according to this division is not provided, insulation coordination is not assured and the risk due to overvoltages shall be evaluated.

This division does not apply in case of overvoltages due to direct or nearby lightning. For protection against transient overvoltages due to direct lightning, the standards of the SASO IEC 61312-1, SASO IEC 61643-1 and SASO IEC 61312-3 are applicable. This division dose not cover overvoltage through data.

NOTE 2 As regards transient atmospheric overvoltages, no distinction is made between earthed and unearthed systems.

44-3.2 Classification of impulse withstand categories (overvoltage categories)

44-3.2.1 Purpose of classification of impulse withstand categories (overvoltage categories)

NOTE 1 Overvoltage categories are defined within electrical installations for the purpose of insulation co-ordination and a related Classification of equipment with impulse withstand voltages is provided, see Table 44-2.

NOTE 2 The rated impulse withstand voltage is an impulse withstand voltage assigned by the manufacturer to the equipment or to a part of it, characterizing the specified withstand capability of its insulation against overvoltages (in accordance with IEC (IEC 6069). The impulse withstand voltage (overvoltage category) is used to classify equipment energized directly from the mains.

Impulse withstand voltages for equipment selected according to the nominal voltage are provided to distinguish different levels of availability of equipment with regard to continuity of service and an acceptable risk of failure. By selection of equipment with a classified impulse withstand voltage; insulation coordination can be achieved in the whole installation, reducing the risk of failure to an acceptable level.

44-3.2.2 Relationship between impulse withstand voltages of equipment and overvoltage categories

Equipment with an impulse withstand voltage corresponding to overvoltage category IV is suitable for use at, or in the proximity of, the origin of the installation, for example upstream of the main distribution board. Equipment of category IV has a very high impulse withstand capability providing the required high degree of reliability.

NOTE 1 Examples of such equipment are electricity meters, primary overcurrent protection devices and ripple control units.

Equipment with an impulse withstand voltage corresponding to overvoltage category III is for use in the fixed installation downstream of, and including the main distribution board, providing a high degree of availability.

NOTE 2 Examples of such equipment are distribution boards, circuit-breakers, wiring systems, including cables, busbars, junction boxes, switches, socket-outlets) in the fixed installation, and equipment for industrial use and some other equipment, e.g. stationary motors with permanent connection to the fixed installation.

Equipment with an impulse withstands voltage corresponding to overvoltage category II is suitable for connection to the fixed electrical installation, providing a normal degree of availability normally required for current-using equipment.

NOTE 3 Examples of such equipment are household appliances and similar loads.

Equipment with an impulse withstand voltage corresponding to overvoltage category I is only suitable for use in the fixed installation of buildings where protective means are applied outside the equipment to limit transient overvoltages to the specified level.

NOTE 4 Examples of such equipment are those containing electronic circuits like computers, appliances with electronic programmes, etc.

Equipment with an impulse withstand voltage corresponding to overvoltage category I shall not have direct connection to a public supply system.

44-3.3 Arrangements for overvoltage control

Overvoltage control is arranged in accordance with the following requirements.

44-3.3.1 Inherent overvoltage control

This statement does not apply when a risk assessment according to 44-3.3.2.2 is used.

Where an installation is supplied by a completely buried low-voltage system and does not include overhead lines, the impulse withstand voltage of equipment in accordance with Table 44-2 is sufficient and no specific protection against overvoltages of atmospheric origin is necessary.

NOTE 1 A suspended cable having insulated conductors with earthed metallic screen is considered as equivalent to an underground cable.

Where an installation is supplied by or includes a low-voltage overhead line and the keraunic level is lower than or equal to 25 days per year (AQ 1), no specific protection against overvoltages of atmospheric origin is required.

NOTE 2 Irrespective of the AQ value protection against overvoltages may be necessary in applications where a higher reliability or higher risks (e.g. fire) are expected.

In both cases, consideration regarding protection against transient overvoltages shall be given to equipment with an impulse withstand voltage according to overvoltage category I (see 44-3.2.2).

44-3.3.2 Protective overvoltage control

The decision as to which of the following methods are applied in a country

with regard to the provision of surge protective devices (SPDs) is left to the national committee based on the local conditions.

In all cases, consideration regarding protection against transient overvoltages shall be given to equipment with an impulse withstand voltage according to overvoltage category I (see 44-3.2.2).

44-3.3.2.1 Protective overvoltage control based on conditions of external influences

Where an installation is supplied by, or includes an overhead line, and the keraunic level of the location is greater than 25 days per year (AQ 2), protection against overvoltages of atmospheric origin is required. The protection level of the protective device shall not be higher than the level of overvoltage category II, given in Table 44-2.

NOTE 1 The overvoltage level may be controlled by surge protective devices applied close to the origin of the installation either in the overhead lines (see annex B.44) or in the building installation.

NOTE 2 According to 802.2 of PART EIGHT and SASO 1614, 25 thunderstorm days per year are equivalent to a value of 2.24 flashes per km^2 per year. This is derived from the formula given in 802-2.2 of PART EIGHT

$$N_g = 0.04\ T_d^{\ 1.25}$$

Where:

N_g is the frequency of flashes per km^2 per year;

T_d is the number of thunderstorm days per year (keraunic level).

44-3.3.2.2 Protective overvoltage control based on risk assessment

NOTE 1 A method of general risk assessment is described in SASO IEC 61662. As far as 44-3 is concerned, an essential simplification of this method has been accepted. It based on the critical length d_c of the incoming lines and the level of consequences as described below.

The following are different consequential levels of protection:

a) consequences related to human life, e.g. safety services, medical equipment in hospitals;

b) consequences related to public services, e.g. loss of public services, Information Technology centers, museums;

c) consequences to commercial or industrial activity, e.g. hotels, banks, industries, commercial markets, farms;

d) consequences to groups of individuals, e.g. large residential buildings, churches, offices, schools;

e) consequences to individuals, e.g. residential buildings, small offices.

For levels of consequences a) to c), protection against overvoltage shall be provided.

NOTE 2 There is no need to perform a risk assessment calculation according to annex D for levels of consequences a) to c) because this calculation always leads to the result that the protection is required.

For levels of consequences d) and e), requirement for protection depends on the result of a calculation. The calculation shall be carried out using the formula in Annex D for the determination of the length d, which is based on a convention and called conventional length.

Protection is required if:

$$d > d_c$$

Where:

d is the conventional length in km of the supply line of the considered structure with a maximum value of 1 km;

d_c is the critical length;

d_c in km, is equal to $1/N_g$ for level of consequences d) and equal to $2/N_g$ for level of consequences e) where N_g is the frequency of flashes per km^2 per year.

If this calculation indicates that an SPD is required, the protection level of these protective devices shall not be higher than the level of overvoltage category II, given in Table 44-2.

44-3.4 Required impulse withstand voltage of equipment

Equipment shall be selected so that its rated impulse withstand voltage is not less than the required impulse withstand voltage as specified in Table 44-2. It is the responsibility of each product committee to require the rated impulse withstand voltage in the relevant standard according to SASO…….

Table 44-2 Required rated impulse withstand voltage of equipment

Nominal voltage of the installation V[a]	**Required impulse withstand voltage for KV[b]**			
Three-phase systems [b]	**Equipment at the origin of the installation (overvoltage category IV)**	**Equipment of distribution and final circuits (overvoltage category III)**	**Appliances and current-using equipment (overvoltage category II)**	**Specially protected equipment (overvoltage category I)**
127/220	4	2.5	1.5	0.8
220/380	6	4	2.5	1.5

[a] According to SASO 182.

[b] This impulse withstand voltage is supplied between live conductors and PE.

44-4 Protection against electromagnetic influences

44-4.1 Measures against electric and magnetic influences on electrical equipment

Measures to be taken against electric and magnetic influences on electrical equipment:

All electrical equipment shall meet the appropriate electromagnetic compatibility (EMC) requirements and shall be in accordance with the relevant EMC standards.

Reference is also made to 51-5.3, Electromagnetic compatibility (EMC) and 51-5.3.1, Choice of the immunity and emission levels, of Chapter 51.

Furthermore, reference is made to Chapter 54.

Consideration shall be given by the planner and designer of the electrical installations to the following (see also Figure 44-14) for reducing the effect of induced overvoltages and (Electromagnetic Interferance) EMI.

44-4.1.1 Location of potential sources of interference relative to sensitive equipment.

44-4.1.2 Location of sensitive equipment relative to high electrical current such as in busbars or in equipment; e.g. lifts.

44-4.1.3 Provision of filters and/or surge protective devices in the circuits feeding sensitive electrical equipment.

44-4.1.4 Selection of protective devices with appropriate time delay characteristics to avoid unwanted tripping on transients.

44-4.1.5 Bonding of metal enclosures and screening.

44-4.1.6 Adequate separation (distance or screening) of power and signal cables, and crossovers at right angles.

44-4.1.7 Adequate separation (distance or screening) of power and signal cables from down conductors of Lighting Protection System (LPS) (see SASO IEC 61024-1, and Figure 44-15).

44-4.1.8 Avoidance of inductive loops by selection of a common route for the wiring of different systems (see also 44-4.2.4).

44-4.1.9 Use of screened and/or twisted pair signal cables.

44-4.1.10 Bonding connections to be made as short as possible.

44-4.1.11 Wiring systems with single-core conductors to be enclosed in bonded metallic enclosures or equivalent.

44-4.1.12 Avoidance of TN-C system in installations with sensitive equipment (see Figure 44-11a as well as statements of chapter 707). For buildings which have, or are likely to have, significant information technology equipment installed, consideration shall be given to the use of separate protective conductors (PE) and neutral conductors (N) beyond the incoming supply point, in order to minimize the possibility of electromagnetic problems due to the diversion of neutral current through signal cables causing damage or interference.

44-4.1.13 For TN-C-S systems within the building, there are two possibilities, depending on the arrangement for interconnection of equipment and extraneous conductive parts:

- change of the TN-C section of the TN-C-S system into a TN-S section for distribution within the building (see Figures 44-11a, 44-11b and 44-12);
- avoidance of excessive loops between different TN-S sections of the TN-C-S system within the building (see Figure 44-11b).

44-4.1.14 Metal pipes (e.g. for water, gas or heating cables), and cables should enter the building at the same place. Metal sheets, screens, metal pipes and connections of these parts shall be bonded and connected to the main equipotential bonding (MEB) of the building (see Figure 44-13) with low impedance conductors.

44-4.1.15 In the case of different areas, which have separated equipotential bonding systems, the use of metal-free fibre optic cable or other non-conducting systems should be used between these different areas.

NOTE The problem of earth differential voltages on large public telecommunication networks is the responsibility of the network operator, who may employ other methods.

44-4.2 Measures for signal connections

In buildings which include a PEN conductor, or where there is EMI on signal cables due to inadequate provisions in the electrical installations, the following methods may be considered to avoid or minimize the problem.

44-4.2.1 Use of fibre optic links for signal connections.

44-4.2.2 Use of class II equipment.

44-4.2.3 Use of local transformers with separate windings (double-wound transformers) for the supply of the information technology equipment, taking into account the requirements of 31-2.2.3 and 41-3.1.5 for IT systems (local IT systems), or of 41-3.5 of, for protection by electrical separation (e.g. transformers according to SASO IEC 60742).

44-4.2.4 Use of suitable wiring (cabling) routing in order to minimize the enclosed area of common loops formed by the supply cables and signal cables.

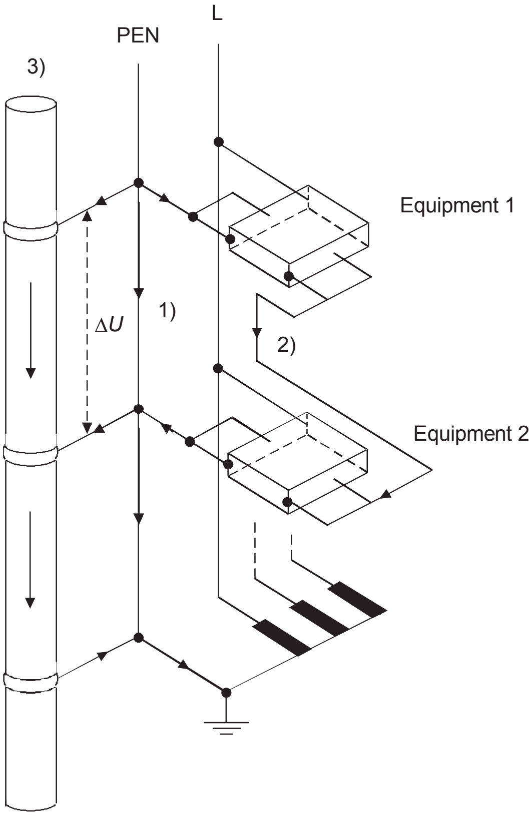


Figure 44-11a TN-C system

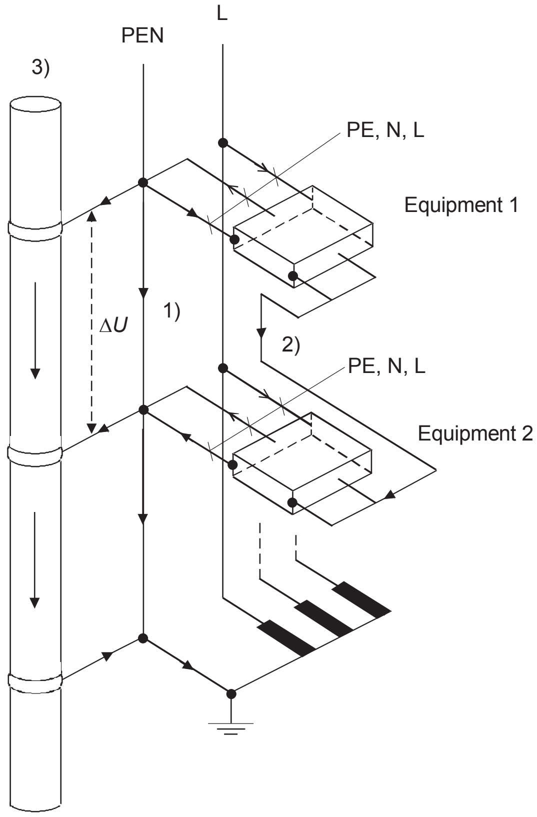


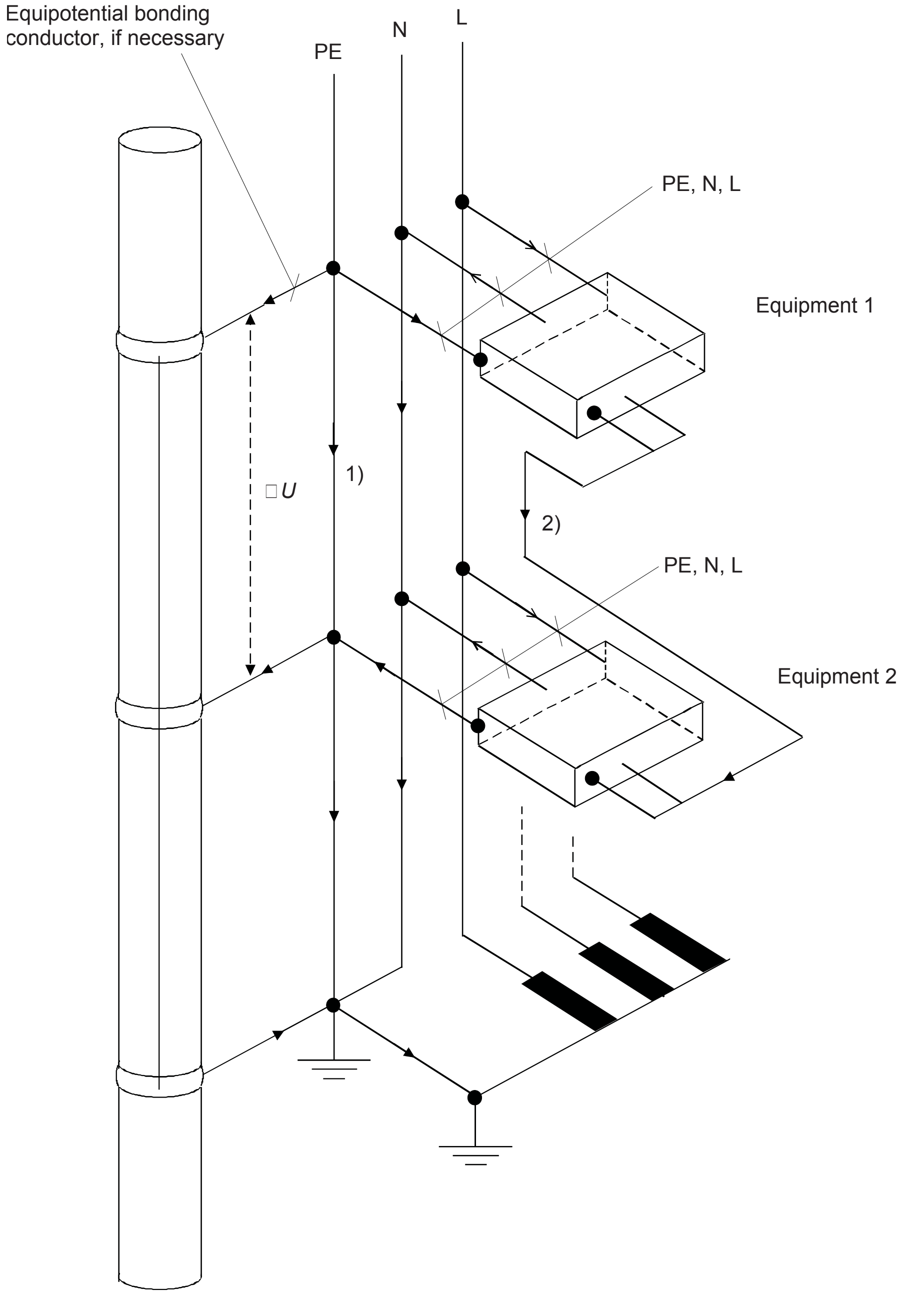
Figure 44-11b TN-C-S system

Key

1) Voltage drop ΔU along PEN
2) Loop of limited area
3) Extraneous-conductive-part

NOTE In a TN-C system, the current which in a TN-S system would flow only through the neutral conductor, flows also through the screens or reference conductors of signal cables, exposed-conductive-parts, and extraneous-conductive-parts such as structural metal work.

Figure 44-11 TN-C and TN-C-S systems in a building



Key

1) Avoidance of voltage drop ΔU along the PE
2) Loop of limited area

NOTE The TN-S system avoids the sharing of the neutral current described in figure 44-12.

Figure 44-12 Avoidance of neutral conductor currents in a bonding structure by using the TN-S system within the building system

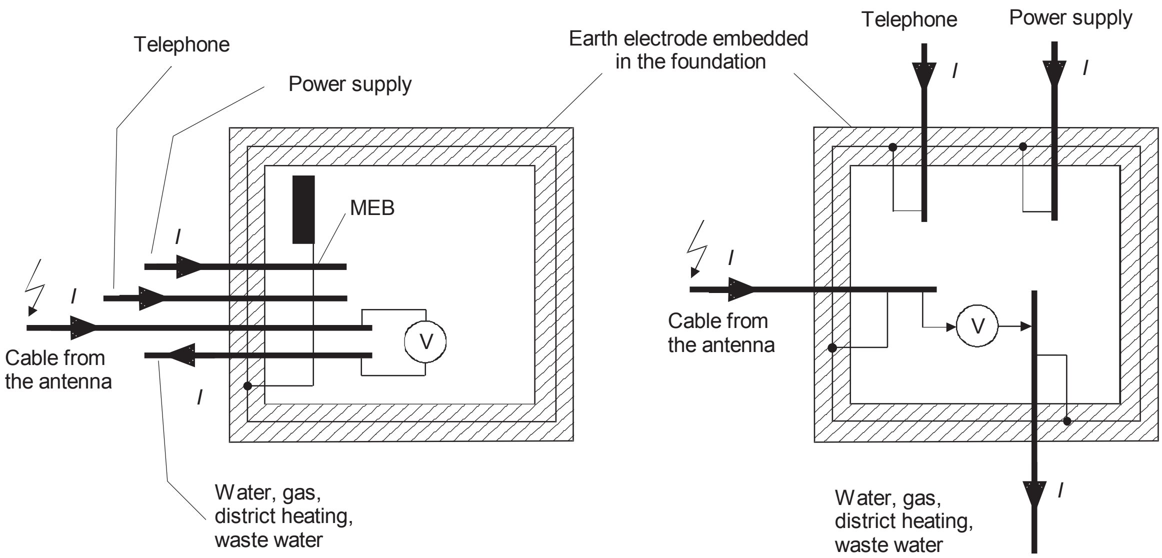


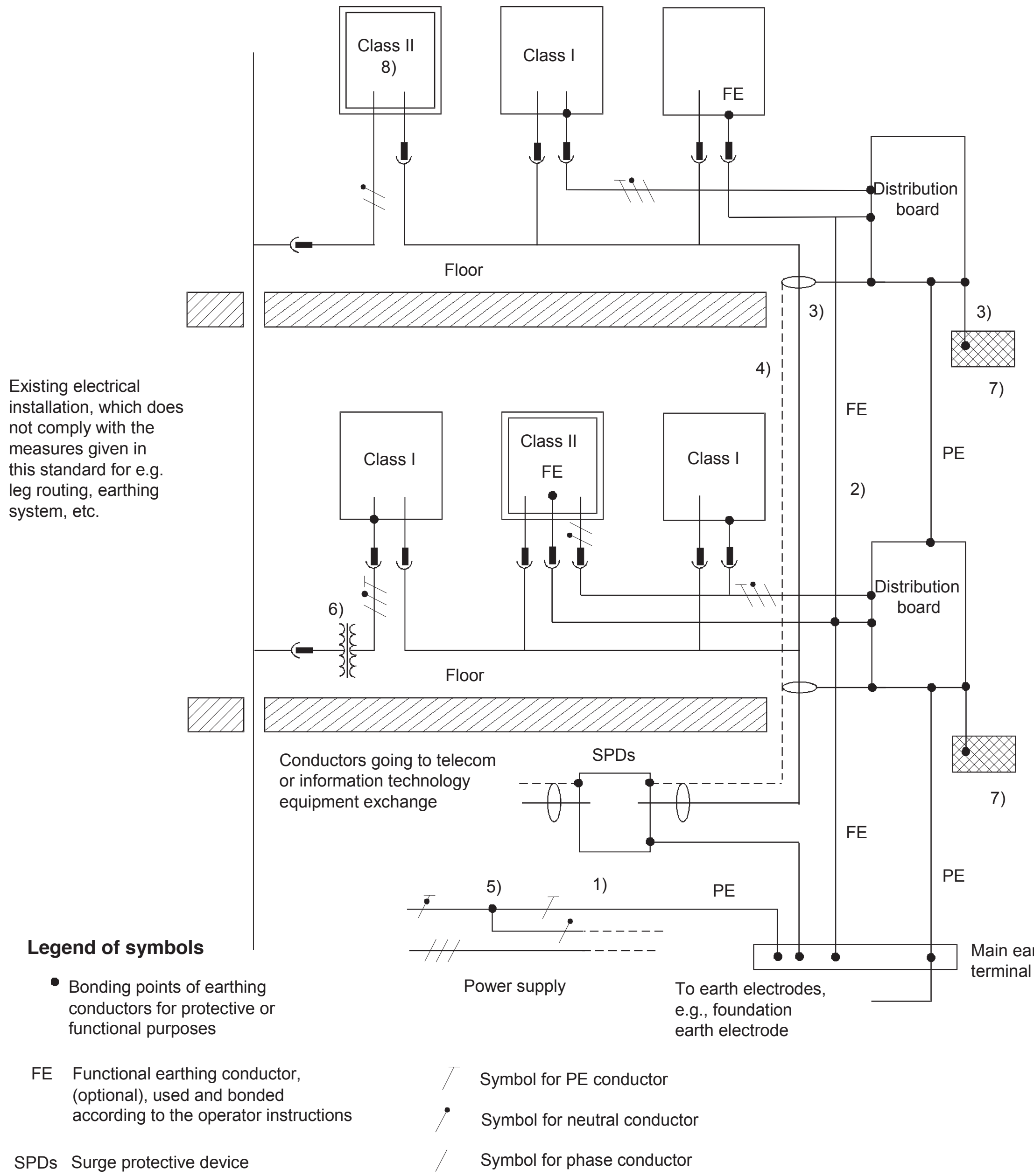
Figure 44-13a
A common entry point is preferred:
$U \cong 0$ V

Figure 44-13b
Entry at different places should be avoided:
$U \neq 0$ V

Key

MEB main equipotential bonding
I induction current

Figure 44-13 Armoured cables and metal pipes entering the buildings (examples)



Statement	Description of the illustrated measures	Reference
44-4.1.14	Cables and metal pipes enter the building at the same place	1)
44-4.1.8	Common route with adequate separations and avoidance of loops	2)
SASO IEC61000-2-5; 44-4.1.10	Bondings as short as possible, and use of earthed conductor parallel to a cable	3)
44-4.1.9	Signal cables screened and/or conductors twisted pairs	4)
44-4.1.12	Avoidance of TN-C beyond the incoming supply point	5)
44-4.1.3	Use of transformers with separate windings	6)
Chapter 54, annex B.54	Local horizontal bonding system, if available	7)
44-4.2.2	Use of class II equipment	8)

Figure 44-14 Illustration of measures described in these Electrical Requirements in an existing building

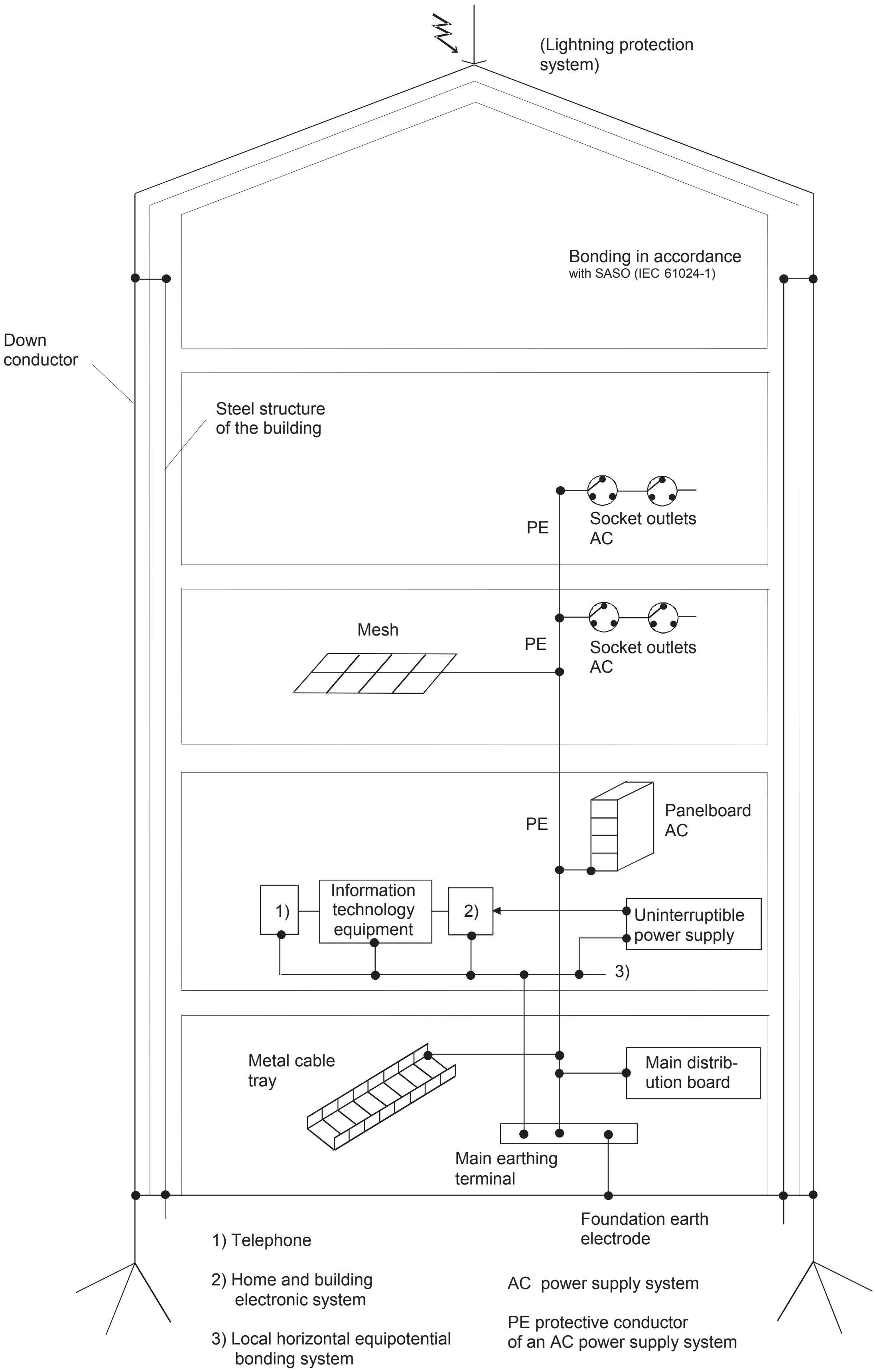


Figure 44-15 Overview of an earthing system of building according to Chapter 54, SASO IEC 61000-2-5 and SASO IEC 61024-1

44-5 Protection against undervoltage

44-5.1 General requirements

44-5.1.1 Where a drop in voltage, or a loss and subsequent restoration of voltage could imply dangerous situations for persons or property, suitable precautions shall be taken. Also, precautions shall be taken where a part of the installation or current-using equipment may be damaged by a drop in voltage.

An undervoltage protective device is not required if damage to the installation or to current-using equipment is considered to be an acceptable risk, provided that no danger is caused to persons. It shall be verified, in consultation with the person or body responsible for the operation and maintenance, if the installation, that foreseen is an acceptable risk.

44-5.1.2 The operation of undervoltage protective devices may be delayed if the operation of the appliance protected allows without danger a brief interruption or loss of voltage.

44-5.1.3 If contactors are used, delay in their opening and reclosing shall not impede instantaneous disconnection by control or protective devices.

44-5.1.4 The characteristics of the undervoltage protective device shall be compatible with the requirements of the relevant standards for starting and use of equipment.

44-5.1.5 Where the reclosure of a protective device is likely to create a dangerous situation, the reclosure shall not be automatic.

Annex A.44
(informative)

Explanatory Notes Concerning 44-2.1 and 44-2.1.2

A.44-2.1 General

The rules in these two statements are intended to provide for the safety of persons and equipment in an LV system in the event of an earth-fault in the HV system.

Faults between systems at different voltages refer to those that may occur on the high-voltage side of the sub-station supplying a low-voltage system through a distribution system operating at a higher voltage. Such faults cause a current to flow in the earth electrode to which the exposed-conductive-parts of the sub-station are connected.

The magnitude of the fault-current depends on the fault-loop impedance, i.e. on how the high-voltage neutral is earthed.

The fault-current flowing in the earth electrode of the exposed-conductive-parts of the sub-station causes a rise of the potential with respect to earth of the exposed-conductive-parts of the sub-station whose magnitude is governed by:

- the fault-current magnitude, and
- the resistance of the earth electrode of the exposed-conductive-parts of the sub-station.

The fault-voltage may be as high as several thousand volts and, depending on the earthing systems of the installation, may cause:

- a general rise of the potential of the low-voltage system with respect to earth, which may cause a breakdown in the low-voltage equipment,
- a general rise of the potential of the exposed-conductive-parts of the low-voltage system with respect to earth, which may give rise to fault and touch-voltages.

It usually takes longer to clear a fault in a high-voltage system than in a low-voltage system, because the relays have time delays for discrimination against unwanted tripping on transients. The operating times of the high-voltage switchgear are also longer than for low-voltage switchgear. This means that the resulting duration of the fault-voltage and the corresponding touch-voltage on the exposed-conductive-parts of the low-voltage system may be longer than required by the LV installation rules.

There may also be a risk of breakdown in the low-voltage system of the sub-station or consumer's installation. The operation of protective devices under abnormal conditions of transient recovery voltages may give rise to difficulties in opening the circuit or even failure to do so.

The following fault conditions in the high-voltage system are taken into consideration:

Effectively earthed high-voltage systems

These systems include those systems where the neutral is connected to earth either directly or via a low impedance and where earth faults are cleared in a reasonably short time given by the protective equipment.

No connection of the neutral to earth in the relevant transformer sub-station is considered.

In general, capacitive currents are neglected.

Isolated high-voltage systems

Only single-fault conditions due to a first earth fault between a high-voltage live-part and exposed-conductive-parts of the transformer sub-station are taken into account. This (capacitive) current may or may not be interrupted, depending on its magnitude and the protective system.

High-voltage systems with arc-suppression coils

No arc-suppression coils in the relevant transformer sub-station are considered.

Where an earth fault in the high-voltage system occurs between a high-voltage conductor and the exposed-conductive-parts of the transformer sub-station, only small fault currents occur (residual currents mostly in the order of some tens of amperes). These currents may persist for longer times.

A.44-2.1.2 Fault-voltage

Figure 44-1 has been derived from curve c_1 of Figure 14 of SASO IEC 60479-1.

When considering the values for the fault-voltage, the following should be taken into account:

a) the low risk of an earth-fault in the HV system;

b) the fact that the touch voltage is always lower than the fault-voltage due to the main equipotential bonding required in 41-3.1.1.2 of Chapter 41 and the presence of additional earth electrodes at the consumer's installation or elsewhere.

Annex B.44
(informative)

Guidance for Overvoltage Control by SPDs Applied to Overhead Lines According to Note 1 of 44-3.3.2.1

In the conditions of 44-3.3.2.1 and according to NOTE 1, the protective control of the overvoltage level may be obtained either by installing surge protective devices directly in the installation, or with the consent of the network operator, in the overhead lines of the supply distribution network.
As an example, the following measures may be applied:

a) in the case of overhead supply distribution networks, overvoltage protection is erected at network junction points and especially at the end of each feeder longer than 500 m. Overvoltage protective devices should be erected at every 500 m distance along the supply distribution lines. The distance between overvoltage protective devices should be less than 1 000 m;

b) if a supply distribution network is erected partly as overhead network and partly as underground network, overvoltage protection in the overhead lines should be applied in accordance with a) at each transition point from and overhead line to an underground cable;

c) in a TN distribution network supplying electrical installations, where protection against indirect contact is provided by automatic disconnection of supply, the earthing conductors of the overvoltage protective devices connected to the line conductors are connected to the PEN conductor or to the PE conductor;

d) in a TT distribution network supplying electrical installations, where protection against indirect contact is provided by automatic disconnection of supply, overvoltage protective devices are provided for the phase conductors and for the neutral conductor. At the place where the neutral conductor of the supply network is effectively earthed, an overvoltage protective device for the neutral conductor is not necessary.

Table B.44-1 Different possibilities for IT systems (taking into account a first fault in the LV installation)

(see 44-2.4.4)

System	Exposed-conductive-parts of LV equipment of the sub-station	Neutral impedance, if any	Exposed-conductive-parts of equipment of the LV installation	U_1	U_2	U_f
a	●	●	●	$U_0\sqrt{3}$	$U_0\sqrt{3}$	$R \times I_m$
b	●	●	0	$U_0\sqrt{3}$	$R \times I_m + U_0\sqrt{3}$	0[a]
c[b]	0	0	0	$R \times I_m + U_0\sqrt{3}$	$U_0\sqrt{3}$	0[a]
d	0	●	●	$R \times I_m + U_0\sqrt{3}$	$U_0\sqrt{3}$	0[a]
e[b]	●	0	●	$R \times I_m + U_0\sqrt{3}$	$R \times I_m + U_0\sqrt{3}$	$R \times I_m$

[a] In fact, U_f is equal to the product of first fault current by the resistance of the earth electrode of the exposed-conductive-parts ($R_A \times I_d$) which shall be less or equal to U_L.

Further, in systems a, b and d, the capacitive currents which flow through the first fault may increase in certain cases the value of U_f, but this is disregarded.

[b] In systems c1 and e1, an impedance is installed between the neutral and earth (impedance neutral).

In systems c2 and e2, no impedance is installed between the neutral and earth (isolated neutral).

Figures 44-4 to 44-10 give the various possibilities of earthing arrangements, with or without a first fault at the consumer's installation.

PART FIVE

SELECTION AND ERECTION
OF
ELECTRICAL EQUIPMENT

CHAPTER 51
COMMON RULES

51-0.1 Scope

This chapter deals with the selection of equipment and its erection. It provides common rules for compliance with measures of protection for safety, requirements for proper functioning for intended use of the installation, and requirements appropriate to the external influences foreseen.

51-0.3 General

Every item of equipment shall be selected and erected so as to allow compliance with the rules stated in this chapter and the relevant rules in other parts of these Electrical Requirements.

51-1 Compliance with standards

51-1.1 Every item of equipment shall comply with its relevant requirements of the latest edition of Saudi, IEC and/or ISO Standards.

51-1.2 Where there are no applicable Saudi, IEC or ISO Standards, the item of equipment concerned shall be selected by special agreement between the person specifying the installation, and the installer without jeopardizing the safety degrees as afforded by these Electrical Requirements.

51-2 Operational conditions and external influences

51-2.1 Operational conditions

51-2.1.1 Voltage

Equipment shall be suitable for the nominal voltage (r.m.s. value for a.c.) of the installation.

If, in IT installations, the neutral conductor is distributed, equipment connected between phase and neutral shall be insulated for the voltage between phases.

NOTE For certain equipment, it may be necessary to take into account of the highest and/or lowest voltage likely to occur in normal service.

51-2.1.2 Current

Equipment shall be selected for the design current (r.m.s. value for a.c.), which it has to carry in normal service.

Equipment shall also be capable of carrying the currents likely to flow in abnormal conditions for such periods as are determined by the characteristics of the protective devices.

51-2.1.3 Frequency

If frequency has an influence on the characteristics of equipment, the rated frequency of the equipment shall correspond to the frequency of the current in the circuit concerned.

51-2.1.4 Power

Equipment selected for its power characteristics shall be suitable for the normal operational conditions taking account of the load factor.

51-2.1.5 Compatibility

Unless other suitable precautions are taken during erection, all equipment shall be selected so that it will not cause harmful effects on other equipment nor impair the supply during normal service, including switching operations.

51-2.2 External influences

51-2.2.1 Electrical equipment shall be selected and erected in accordance with the requirements of Table 51-1, which indicates the characteristics of equipment necessary according to the external influences to which the equipment may be subjected.

Equipment characteristics shall be determined either by a degree of protection or by conformity to tests.

51-2.2.2 If the equipment does not, by its construction, have the characteristics relevant to the external influences of its location, it may nevertheless be used on condition that it is provided with appropriate additional protection in the erection of the installation. Such protection shall not adversely affect the operation of the equipment thus protected.

51-2.2.3 When different external influences occur simultaneously, which may have independent or mutual effect then the degree of protection shall be provided accordingly.

51-2.2.4 The selection of equipment according to external influences is necessary not only for proper functioning, but also to ensure the reliability of the measures of protection for safety complying with the rules of these Electrical Requirements generally. Measures of protection afforded by the construction of equipment are valid only for the given conditions of external influence if the corresponding equipment specification tests are made in these conditions of external influence.

NOTE 1 For the purpose of these Electrical Requirements, the following classes of external influences are conventionally regarded as normal:

AA Ambient temperature	AA4, AA5
AB Atmospheric humidity	AB4, AB5
Other environmental conditions (AC to AR)	XX1 of each parameter
Utilization and construction of buildings (B and C)	XX1 of each parameter, except XX2 for the parameter BC

NOTE 2 The word "normal" appearing in the third column of the table signifies that the equipment must generally satisfy applicable Saudi or IEC Standards.

Table 51-1 Characteristics of external influences

Code	External influences	Characteristics required for selection and erection of equipment	Reference
A	*Environmental conditions*		
AA	*Ambient temperature* The ambient temperature is that of the ambient air where the equipment is to be installed. It is assumed that the ambient temperature includes the effects of other equipment installed in the same location. The ambient temperature to be considered for the equipment is the temperature at the place where the equipment is to be installed resulting from the influence of all other equipment in the same location, when operating, not taking into account the thermal contribution of the equipment to be installed. Lower and upper limits of ranges of ambient temperature:		
AA1	–60 °C +5°C	Specially designed equipment or appropriate arrangements[a]	Includes temperature range of SASO IEC 60721-3-3, class 3K8, with high air temperature restricted to +5°C. Part of temperature range of SASO IEC 60721-3-4, class 4K4, with low air temperature restricted to –60°C and high air temperature restricted to +5°C
AA2	–40 °C +5°C		Part of temperature range of SASO IEC 60721-3-3, class 3K7, with high air temperature restricted to +5°C. Includes part of temperature range of SASO IEC 60721-3-4, class 4K3, with high air temperature restricted to +5°C
AA3	–25 °C +5°C		Part of temperature range of SASO IEC 60721-3-3, class 3K6, with high air temperature restricted to +5°C. Includes temperature range of SASO IEC 60721-3-4, class 4K1, with high air temperature restricted to +5°C
AA4	–5 °C +40°C	Normal (in certain cases special precautions may be necessary)	Part of the temperature range of SASO IEC 60721-3-3, class 3K5, with the high air temperatures restricted to +40°C
AA5	+5°C +40°C	Normal	Identical to temperature range of SASO IEC 60721-3-3, class 3K3

[a] May necessitate certain supplementary precautions (e.g. special lubrication).

[b] This means that ordinary equipment will operate safely under the described external influences.

[c] This means that special arrangements should be made, for example, between the designer of the installation and the equipment manufacturer, e.g. for specially designed equipment.

Table 51-1 *(continued)*

Code	External influences	Characteristics required for selection and erection of equipment	Reference
AA6	+5 °C +60°C	Specially designed equipment or appropriate arrangements[a]	Part of temperature range of SASO IEC 60721-3-3, class 3K7, with low air temperature restricted to +5°C and high air temperature restricted to +60°C. Includes temperature range of SASO IEC 60721-3-4, class 4K4 with low air temperature restricted to +5°C
AA7	–25 °C +55°C	Specially designed equipment or appropriate arrangements[a] (applies to AA7 and AA8)	– Identical with temperature range of SASO IEC 60721-3-3, class 3K6
AA8	–50 °C +40°C Ambient temperature classes are applicable only where humidity has no influence. The average temperature over a 24 h period must not exceed 5°C below the upper limits. Combination of two ranges to define some environments may be necessary. Installations subject to temperatures outside the ranges require special consideration.		– Identical with temperature range of SASO IEC 60721-3-4, class 4K3
AB	*Atmospheric humidity* **Air temperature** °C **a) low b) high** / **Relative humidity** % **c) low d) high** / **Absolute humidity** g/m^3 **e) low f) high**		
AB1	Air temperature: –60 / +5; Relative humidity: 3 / 100; Absolute humidity: 0.003 / 7	Indoor and outdoor locations with extremely low ambient temperatures Appropriate arrangements shall be made.[c]	Includes temperature range of SASO IEC 60721-3-3, class 3K8, with high air temperature restricted to +5°C. Part of temperature range of SASO IEC 60721-3-4, class 4K4, with low air temperature restricted to –60°C and high air temperature restricted to +5°C
AB2	Air temperature: –40 / +5; Relative humidity: 10 / 100; Absolute humidity: 0.1 / 7	Indoor and outdoor locations with low ambient temperatures Appropriate arrangements shall be made.[c]	Part of temperature range of SASO IEC 60721-3-3, class 3K7, with high temperature restricted to +5°C. Part of temperature range of SASO IEC 60721-3-4, class 4K4, with low air temperature restricted to –60°C and high air temperature restricted to +5°C

[a] May necessitate certain supplementary precautions (e.g. special lubrication).

[b] This means that ordinary equipment will operate safely under the described external influences.

[c] This means that special arrangements should be made, for example, between the designer of the installation and the equipment manufacturer, e.g. for specially designed equipment.

Table 51-1 *(continued)*

Code	External influences						Characteristics required for selection and erection of equipment	Reference
	Air temperature °C **a) low**	**b) high**	**Relative humidity** % **c) low**	**d) high**	**Absolute humidity** g/m³ **e) low**	**f) high**		
AB3	–25	+5	10	100	0.5	7	Indoor and outdoor locations with low ambient temperatures Appropriate arrangements shall be made.[c]	Part of temperature range of SASO IEC 60721-3-3, class 3K6, with high air temperature restricted to +5°C. Includes temperature range of SASO IEC 60721-3-4, class 4K1, with high air temperature range restricted to +5°C
AB4	–5	+40	5	95	1	29	Weather protected locations having neither temperature nor humidity control. Heating may be used to raise low ambient temperatures. Normal[b]	Identical with temperature range of SASO IEC 60721-3-3, class 3K5. The high air temperature restricted to +40°C
AB5	+5	+40	5	85	1	25	Weather protected locations with temperature control Normal[b]	Identical with temperature range of SASO IEC 60721-3-3, class 3K3
AB6	+5	+60	10	100	1	35	Indoor and outdoor locations with extremely high ambient temperatures, influence of cold ambient temperatures is prevented. Occurrence of solar and heat radiation. Appropriate arrangements shall be made.[c]	Part of temperature range of SASO IEC 60721-3-3, class 3K7, with low air temperature restricted to +5°C and high air temperature restricted to +60°C. Includes temperature range of SASO IEC 60721-3-4, class 4K4, with low air temperature restricted to +5°C
AB7	–25	+55	10	100	0.5	29	Indoor weather protected locations having neither temperature nor humidity control, the locations may have openings directly to the open air and be subjected to solar radiation. Appropriate arrangements shall be made.[c]	Identical with temperature range of SASO IEC 60721-3-3, class 3K6
AB8	–50	+40	15	100	0.04	36	Outdoor and non-weather protected locations, with low and high temperatures Appropriate arrangements shall be made.[c]	Identical with temperature range of SASO IEC 60721-3-4, class 4K3

[a] May necessitate certain supplementary precautions (e.g. special lubrication).

[b] This means that ordinary equipment will operate safely under the described external influences.

[c] This means that special arrangements should be made, for example, between the designer of the installation and the equipment manufacturer, e.g. for specially designed equipment.

Table 51-1 *(continued)*

Code	External influences	Characteristics required for selection and erection of equipment	Reference
AC	*Altitude*		
AC1	α 2 000 m	Normal[b]	
AC2	>2 000 m	May necessitate special precautions such as the application of derating factors. NOTE For some equipment special arrangements may be necessary at altitudes of 1 000 m and above.	
AD	*Presence of water*		
AD1	Negligible	IPX0 Outdoor and non-weather protected locations, with low and high temperatures	SASO IEC 60721-3-4 class 4Z6
AD2	Free-falling drops	IPX1 or IPX2 Location in which water vapour occasionally condenses as drops or where steam may occasionally be present.	SASO IEC 60721-3-3 class 3Z7
AD3	Sprays	IPX3 Locations in which sprayed water forms a continuous film on floors and/or walls	SASO IEC 60721-3-3 class 3Z8 SASO IEC 60721-3-4 class 4Z7
AD4	Splashes	IPX4 Locations where equipment may be subjected to splashed water; this applies, for example, to certain external luminaires, construction site equipment	SASO IEC 60721-3-3 class 3Z9 SASO IEC 60721-3-4 class 4Z7
AD5	Jets	IPX5 Locations where hose water is used regularly (yards, car-washing bays)	
AD6	Waves	IPX6 Seashore locations such as piers, beaches, quays, etc	SASO IEC 60721-3-3 class 3Z10 SASO IEC 60721-3-4 class 4Z8
AD7	Immersion	IPX7 Locations which may be flooded and/or where water may be at maximum 150 mm above the highest point of equipment, the lowest part of equipment being not more than 1 mm below the water surface.	SASO IEC 60721-3-4 class 4Z9
AD8	Submersion	IPX8 Locations such as swimming pools where electrical equipment is permanently and totally covered with water under a pressure greater than 0.1 bar	

[a] May necessitate certain supplementary precautions (e.g. special lubrication).

[b] This means that ordinary equipment will operate safely under the described external influences.

[c] This means that special arrangements should be made, for example, between the designer of the installation and the equipment manufacturer, e.g. for specially designed equipment.

Table 51-1 *(continued)*

Code	External influences	Characteristics required for selection and erection of equipment	Reference
AE	*Presence of foreign solid bodies*	IPXX see also 41-2 of chapter41	
AE1	Negligible	IP0X	SASO IEC 60721-3-3 class 3S1 SASO IEC 60721-3-4 class 4S1
AE2	Small objects (2.5 mm)	IP3X Tools and small objects are examples of foreign solid bodies of which the smallest dimension is at least 2.5 mm	SASO IEC 60721-3-3 class 3S2 SASO IEC 60721-3-4 class 4S2
AE3	Very small objects (1 mm)	IP4X Wires are examples of foreign solid bodies of which the smallest dimension is not less than 1 mm	SASO IEC 60721-3-3 class 3S3 SASO IEC 60721-3-4 class 4S3
AE4	Light dust	IP5X if dust penetration is not harmful to the functioning of the equipment. IP6X if dust should not penetrate equipment	SASO IEC 60721-3-3,.class 3S2 SASO IEC 60721-3-4, class 4S2
AE5	Moderate dust		SASO IEC 60721-3-3, class 3S3 SASO IEC 60721-3-4, class 4S3
AE6	Heavy dust	IP6X	SASO IEC 60721-3-3, class 3S4 SASO IEC 60721-3-4, class 4S4
AF	*Presence of corrosive of polluting substances*		
AF1	Negligible	Normal[b]	SASO IEC 60721-3-3 class 3C1 SASO IEC 60721-3-4 class 4C1
AF2	Atmospheric	According to the nature of substances (for example, satisfaction of salt mist test according to SASO IEC 60068-2-11 Installations situated by the sea or near industrial zones producing serious atmospheric pollution, such as chemical works, cement works; this type of pollution arises especially in the production of abrasive, insulating or conductive dusts.	SASO IEC 60721-3-3 class 3C2 SASO IEC 60721-3-4 class 4C2
AF3	Intermittent or accidental	Protection against corrosion according to equipment specification Locations where some chemicals products are handled in small quantities and where these products may come only accidentally into contact with electrical equipment; such conditions are found in factory laboratories, other laboratories or in locations where hydrocarbons are used (boiler-rooms, garages, etc.)	SASO IEC 60721-3-3 class 3C3 SASO IEC 60721-3-4 class 4C3
AF4	Continuous	Equipment specially designed according to the nature of substances For example, chemical works	SASO IEC 60721-3-3 class 3C4 SASO IEC 60721-3-4 class 4C4
	Mechanical stress		
AG	*Impact*		
AG1	Low severity	Normal, e.g. household and similar equipment	SASO IEC 60721-3-3, classes 3M1/3M2/3M3 SASO IEC 60721-3-4, classes 4M1/4M2/4M3
AG2	Medium severity	Standard industrial equipment, where applicable, or reinforced protection	SASO IEC 60721-3-3, classes 3M4/3M5/3M6 SASO IEC 60721-3-4, classes 4M4/4M5/4M6
AG3	High severity	Reinforced protection	SASO IEC 60721-3-3, classes 3M7/3M8 SASO IEC 60721-3-4, classes 4M7/4M8

[a] May necessitate certain supplementary precautions (e.g. special lubrication).

[b] This means that ordinary equipment will operate safely under the described external influences.

[c] This means that special arrangements should be made, for example, between the designer of the installation and the equipment manufacturer, e.g. for specially designed equipment.

Table 51-1 *(continued)*

Code	External influences	Characteristics required for selection and erection of equipment	Reference
AH	*Vibration*		
AH1	Low severity	Normal[b] Household and similar conditions where the effects of vibration are generally negligible	SASO IEC 60721-3-3, classes 3M1/3M/3M3 SASO IEC 60721-3-4, classes 4M1/4M2/4M3
AH2	Medium severity	Usual industrial conditions Specially designed equipment or special arrangements	SASO IEC 60721-3-3, classes 3M4/3M5/3M6 SASO IEC 60721-3-4, classes 4M4/4M5/4M6
AH3	High severity	Industrial installations subject to severe conditions	SASO IEC 60721-3-3, classes 3M7/3M8 SASO IEC 60721-3-4, classes 4M7/4M8
AJ	*Other mechanical stresses*	Under consideration	
AK	*Presence of flora and/or moulds growth*		
AK1	No hazard	Normal[b]	SASO IEC 60721-3-3, class 3B1 SASO IEC 60721-3-4, class 4B1
AK2	Hazard	The hazard depends on local conditions and the nature of flora. Distinction should be made between harmful growth of vegetation or conditions for promotion of mould growth. Special protection, such as: – increased degree of protection (see AE) – special materials or protective coating of enclosures – arrangements to exclude flora from location	SASO IEC 60721-3-3, class 3B2 SASO IEC 60721-3-4, class 4B2
AL	*Presence of fauna*		
AL1	No hazard	Normal[b]	SASO IEC 60721-3-3, class 3B1 SASO IEC 60721-3-4, class 4B1
AL2	Hazard	The hazard depends on the nature of the fauna. Distinction should be made between: – presence of insects in harmful quantity or of an aggressive nature – presence of small animals or birds in harmful quantity or of an aggressive nature Protection may include: – an appropriate degree of protection against penetration of foreign solid bodies (see AE) – sufficient mechanical resistance (see AG) – precautions to exclude fauna from the location (such as cleanliness, use of pesticides) – special equipment or protective coating of enclosures	SASO IEC 60721-3-3, class 3B2 SASO IEC 60721-3-4, class 4B2

[a] May necessitate certain supplementary precautions (e.g. special lubrication).

[b] This means that ordinary equipment will operate safely under the described external influences.

[c] This means that special arrangements should be made, for example, between the designer of the installation and the equipment manufacturer, e.g. for specially designed equipment.

Table 51-1 *(continued)*

Code	External influences	Characteristics required for selection and erection of equipment	Reference
AM	*Electromagnetic, electrostatic, or ionizing influences*		SASO IEC 61000-2 series and SASO IEC 61000-4 series
	Low-frequency electromagnetic phenomena (conducted or radiated)		
	Harmonics, interharmonics		
AM-1-1	Controlled level	Care should be taken that the controlled situation is not impaired.	Lower than table 1 of SASO IEC 61000-2-2
AM-1-2	Normal level	Special measures in the design of the installation, e.g. filters	Complying with table 1 of SASO IEC 61000-2-2
AM-1-3	High level	(AM-1-2 and AM-1-3 bracketed together)	Locally higher than table 1 of SASO IEC 61000-2-2
	Signalling voltages		
AM-2-1	Controlled level	Possibly: blocking circuits	Lower than specified below
AM-2-2	Medium level	No additional requirement	SASO IEC 61000-2-1 and SASO IEC 61000-2-2
AM-2-3	High level	Appropriate measures	
	Voltage amplitude variations		
AM-3-1	Controlled level		
AM-3-2	Normal level	Compliance with Chapter 44.	
AM-4	*Voltage unbalance*		Compliance with SASO IEC 61000-2-2
AM-5	*Power frequency variations*		± 1 Hz according to SASO IEC 61000-2-2
	Induced low-frequency voltages		
AM-6	No classification	Refer to chapter 44. High withstand of signal and control systems of switchgear and controlgear	ITU-T
	Direct current in a.c. networks (321.10.1.7)		
AM-7	No classification	Measures to limit their presence in level and time in the current-using equipment or their vicinity	
	Radiated magnetic fields		
AM-8-1	Medium level	Normal[b]	Level 2 of SASO IEC 61000-4-8
AM-8-2	High level	Protection by appropriate measures e.g. screening and/or separation	Level 4 of SASO IEC 61000-4-8

[a] May necessitate certain supplementary precautions (e.g. special lubrication).

[b] This means that ordinary equipment will operate safely under the described external influences.

[c] This means that special arrangements should be made, for example, between the designer of the installation and the equipment manufacturer, e.g. for specially designed equipment.

Table 51-1 *(continued)*

Code	External influences	Characteristics required for selection and erection of equipment	Reference
	Electric fields		
AM-9-1	Negligible level	Normal[b]	
AM-9-2	Medium level	Refer to SASO IEC 61000-2-5	SASO IEC 61000-2-5
AM-9-3	High level	Refer to SASO IEC 61000-2-5	
AM-9-4	Very high level	Refer to SASO IEC 61000-2-5	
	High-frequency electromagnetic phenomena conducted, induced or radiated (continuous or transient)		
	Induced oscillatory voltages or currents		
AM-21	No classification	Normal[b]	SASO IEC 61000-4-6
	Conducted unidirectional transients of the nanosecond time scale		SASO IEC 61000-4-4
AM-22-1	Negligible level	Protective measures are necessary	Level 1
AM-22-2	Medium level	Protective measures are necessary (see 32-1.10.2.2)	Level 2
AM-22-3	High level	Normal equipment	Level 3
AM-22-4	Very high level	High immunity equipment	Level 4
	Conducted unidirectional transients of the microsecond to the millisecond time scale		
AM-23-1	Controlled level	Impulse withstand of equipment and overvoltage protective means chosen taking into account the nominal supply voltage and the impulse withstand category according to Chapter 44.	Chapter 44
AM-23-2	Medium level		Chapter 44
AM-23-3	High level		
	Conducted oscillatory transients		
AM-24-1	Medium level	Refer to SASO IEC 61000-4-12	SASO IEC 61000-4-12
AM-24-2	High level	Refer to SASO IEC 60255-22-1	SASO IEC 60255-22-1
	Radiated high-frequency phenomena		SASO IEC 61000-4-3
AM-25-1	Negligible level		Level 1
AM-25-2	Medium level	Normal[b]	Level 2
AM-25-3	High level	Reinforced level	Level 3
	Electrostatic discharges		SASO IEC 61000-4-2
AM-31-1	Small level	Normal[b]	Level 1
AM-31-2	Medium level	Normal[b]	Level 2
AM-31-3	High level	Normal[b]	Level 3
AM-31-4	Very high level	Reinforced	Level 4
AM-41-1	*Ionization* No classification	Special protection such as: – Spacings from source – Interposition of screens, enclosure by special materials	

[a] May necessitate certain supplementary precautions (e.g. special lubrication).

[b] This means that ordinary equipment will operate safely under the described external influences.

[c] This means that special arrangements should be made, for example, between the designer of the installation and the equipment manufacturer, e.g. for specially designed equipment.

Table 51-1 *(continued)*

Code	External influences	Characteristics required for selection and erection of equipment	Reference
AN	*Solar radiation*		
AN1	Low	Normal[b]	SASO IEC 60721-3-3
AN2	Medium	Appropriate arrangements shall be made.[c]	SASO IEC 60721-3-3
AN3	High	Appropriate arrangements shall be made.[c] Such arrangements could be: – material resistant to ultra-violet radiation – special colour coating – interposition of screens	SASO IEC 60721-3-4
AP	*Seismic effects*		
AP1	Negligible	Normal	
AP2	Low severity	Under consideration	
AP3	Medium severity		
AP4	High severity	Vibration, which may cause the destruction of the building, is outside the classification. Frequency is not taken into account in the classification; however, if the seismic wave resonates with the building, seismic effects must be specially considered. In general, the frequency of seismic acceleration is between 0 Hz and 10 Hz.	
AQ	*Lightning*		
AQ1	Negligible	Normal	
AQ2	Indirect exposure	In accordance with 44-3 of chapter 44	
		Installations supplied by overhead lines	
AQ3	Direct exposure	If lightning protection is necessary it shall be arranged according to SASO IEC 61024-1 and SASO IEC 62305. Parts of installations located outside buildings. The risks AQ2 and AQ3 relate to regions with a particularly high level of thunderstorm activity	
AR	*Movement of air*		
AR1	Low	Normal[b]	
AR2	Medium	Appropriate arrangements shall be made.[c]	
AR3	High	Appropriate arrangements shall be made.[c]	
AS	*Wind*		
AS1	Low	Normal[b]	
AS2	Medium	Appropriate arrangements shall be made.[c]	
AS3	High	Appropriate arrangements shall be made.[c]	

[a] May necessitate certain supplementary precautions (e.g. special lubrication).

[b] This means that ordinary equipment will operate safely under the described external influences.

[c] This means that special arrangements should be made, for example, between the designer of the installation and the equipment manufacturer, e.g. for specially designed equipment.

Table 51-1 *(continued)*

Code	External influences	Characteristics required for selection and erection of equipment	Reference
B	*Utilization*		
BA	*Capability of persons*		
BA1	Ordinary	Normal[b]	Inaccessibility of electrical equipment. Limitation of temperature of accessible surfaces
BA2	Children	Equipment of degrees of protection higher than IP2X. Inaccessibility of equipment with external surface temperature exceeding 80°C (60°C or nurseries and the like)	
BA3	Handicapped	According to the nature of the handicap	
BA4	Instructed	Equipment not protected against direct contact admitted solely in locations which are accessible only to duly authorized persons.	
BA5	Skilled		
BB	*Electrical resistance of the human body*	Under consideration	
BC	*Contact of persons with earth potential*	**Class of equipment according to SASO IEC 61140**	
		0-0I I II III	
BC1	None	A Y A A	41-3.3 of Chapter 41
BC2	Low	A A A A	
BC3	Frequent	X A A A	
BC4	Continuous	Under consideration	
		A Equipment permitted X Equipment prohibited Y Permitted if used as class 0	
BD	*Conditions of evacuation in an emergency*		
BD1	(Low density/easy exit)	Normal[b]	
BD2	(Low density/difficult exit)	Equipment made of material retarding the spread of flame and evolution of smoke and toxic gases. Detailed requirements are under consideration.	
BD3	(High density/easy exit)		
BD4	(High density/difficult exit)		
BE	*Nature of processed or stored materials*		
BE1	No significant risks	Normal[b]	
BE2	Fire risks	Equipment made of material retarding the spread of flame. Arrangements such that a significant temperature rise or a spark within electrical equipment cannot initiate an external fire. Barns, wood-working shops, paper factories	Chapter 42 Chapter 51
BE3	Explosion risks	Requirements for electrical apparatus for explosive atmospheres (see SASO IEC 60079), Oil refineries, hydrocarbon stores	

[a] May necessitate certain supplementary precautions (e.g. special lubrication).

[b] This means that ordinary equipment will operate safely under the described external influences.

[c] This means that special arrangements should be made, for example, between the designer of the installation and the equipment manufacturer, e.g. for specially designed equipment.

Table 51-1 *(continued)*

Code	External influences	Characteristics required for selection and erection of equipment	Reference
BE4	Contamination risks	Appropriate arrangements, such as: – protection against falling debris from broken lamps and other fragile objects – screens against harmful radiation such as infra-red or ultra-violet Foodstuff industries, kitchens: certain precautions may be necessary, in the event of fault, to prevent processed materials being contaminated by electrical equipment, e.g. by broken lamps.	
C	*Construction of buildings*		
CA	*Construction materials*		
CA1	Non combustible	Normal[b]	
CA2	Combustible	Under consideration Wooden buildings	Chapter 42
CB	*Building design*		
CB1	Negligible risks	Normal[b]	
CB2	Propagation of fire	Equipment made of material retarding the propagation of fire including fires not originating from the electrical installation. Fire barriers NOTE Fire detectors may be provided. High-rise buildings. Forced ventilation systems	Chapter 42 Chapter 52
CB3	Movement	Contraction or expansion joints in electrical wiring Buildings of considerable length or erected on unstable earth	Contraction or expansion joints chapter 52
CB4	Flexible or unstable	Under consideration Tents, air-support structures, false ceilings, removable partitions. Installations to be structurally self-supporting	Flexible wiring Chapter 52

[A] May necessitate certain supplementary precautions (e.g. special lubrication).

[b] This means that ordinary equipment will operate safely under the described external influences.

[c] This means that special arrangements should be made, for example, between the designer of the installation and the equipment manufacturer, e.g. for specially designed equipment.

51-3 Accessibility

51-3.1 General

All equipment, including wiring, shall be arranged so as to facilitate its operation, inspection and maintenance and access to its connections, except for the joints addressed in 52-6.3. Such facilities shall not be significantly impaired by mounting equipment in enclosures or compartments.

51-4 Identification

51-4.1 General

Doors into electrical control panel rooms shall be marked with a plainly visible and legible sign stating ELECTRICAL ROOM or similar approved wording.

Labels or other suitable means of identification shall be provided to indicate the purpose of switchgear and controlgear, unless there is no possibility of confusion.

Where the functioning of switchgear and controlgear cannot be observed by the operator, and where this might cause a danger, a suitable indicator, complying where applicable with SASO IEC 60073 and SASO IEC 60447, shall be fixed in a position visible to the operator.

51-4.2 Wiring systems

51-4.2.1 Wiring shall be so arranged or marked that it can be identified for inspection, testing, repairs or alteration of the installation.

51-4.2.2 Where an electrical conduit is required, it shall be distinguished from a pipeline or other services.

51-4.2.3 Identification of conductors by colour for new electrical installations shall be according to Table 51-2.

51-4.2.4 Where an alteration or addition is made to an installation wired in the old colours with an addition or extension in the new colours, alphanumeric marking for both old and new conductors at the interface shall be according to Table 51-2.

NOTE The adoption of this marking removes the ambiguity that is always of concern where colours alone are used.

51-4.2.5 Where an alteration or addition has been made a warning sign in Arabic and English shall be fixed at the interface between old and new installations on or near the consumer distribution board from which the circuit having new colours is supplied.

The warning statement may be as follows:

> **Warning**
>
> This installation has two different systems of wiring colours for the old and new installations.
>
> The electricians should take great care before undertaking extension, alteration or repair so that all conductors are correctly identified.

Table 51-2 Identification of conductors by colours and alphanumeric marking

Function	Alphanumeric	Colour
Protective conductors		Green-and-yellow
PEN conductor		Green-and-yellow with blue marking at the terminations
Functional earthing conductor		Cream
a.c. power circuit(1)		
Phase of single-phase circuit	L	Brown
Neutral of single- or three-phase circuit	N	Blue
Phase 1 of three-phase a.c. circuit	L1	Brown
Phase 2 of three-phase a.c. circuit	L2	Black
Phase 3 of three-phase a.c. circuit	L3	Grey
Two-wire unearthed d.c. power circuit		
Positive of two-wire circuit	L+	Brown
Negative of two-wire circuit	L-	Grey
Two-wire earthed d.c. power circuit		
Positive (of negative earthed) circuit	L+	Brown
Negative (of negative earthed) circuit(2)	M	Blue
Positive (of positive earthed) circuit(2)	M	Blue
Negative (of positive earthed) circuit	L-	Grey
Three-wire d.c. power circuit		
Outer positive of two-wire circuit Derived from three-wire system	L+	Brown
Outer negative of two-wire circuit Derived from three-wire system	L-	Grey
Positive of three-wire circuit	L+	Brown
Mid-wire of three-wire circuit(2) (3)	M	Blue
Negative of three-wire circuit	L-	Grey
Control circuits, ELV and other applications		
Phase conductor	L	Brown, Black, Red, Orange, Yellow, Violet, Grey, White, Pink or Turquoise
Neutral or mid-wire(4)	N or M	Blue
NOTES:		
(1) Power circuits include lighting circuits.		
(2) M identifies either the mid-wire of a three-wire d.c. circuit, or the earthed conductor of a two-wire earthed d.c. circuit.		
(3) Only the middle wire of three-wire circuits may be earthed.		
(4) An earthed PELV conductor is blue.		

51-4.3 Protective devices

The protective devices shall be arranged and identified so that the circuits protected may be easily recognized; for this purpose it may be convenient to group them in distribution boards.

51-4.4 Diagrams

51-4.4.1 Where appropriate, diagrams, charts or tables in accordance with SASO IEC 61346-1 and the SASO IEC 61082 series shall be provided, indicating in particular:

- the type and composition of circuits (points of utilization served, number and size of conductors, type of wiring);
- the characteristics necessary for the identification of the devices performing the functions of protection, isolation and switching and their locations.

For simple installations the foregoing information may be given in a schedule.

51-4.4.2 The symbols used shall be chosen from the SASO IEC 60617-1 series.

51-5 Prevention of mutual detrimental influence

51-5.1 Equipment shall be so selected and erected as to avoid any harmful influence between the electrical installation and any non-electrical installations. Equipment not provided with a back plate shall not be mounted on a building surface unless the following requirements are satisfied:

- a voltage transfer to the building surface is prevented;
- fire segregation is provided between the equipment and a combustible building surface.

If the building surface is non-metallic and non-combustible, no additional measures are required. If not, these requirements may be satisfied by one of the following measures:

- if the building surface is metallic, it shall be bonded to the protective conductor (PE) or to the equipotential bonding conductor of the installation, in accordance with 41-3.1.6 and Chapter 54;
- if the building surface is combustible, the equipment shall be separated from it by a suitable intermediate layer of insulating material having a flammability rating of FH1 according to SASO IEC 60707.

51-5.2 Where equipment carrying currents of different types or at different voltages is grouped on a common assembly (such as a switchboard, a cubicle or a control desk or box), all the equipment belonging to any one type of current or any one voltage shall be effectively segregated wherever necessary to avoid mutual detrimental influence.

51-5.3 Electromagnetic compatibility

51-5.3.1 Choice of the immunity and emission levels

51-5.3.1.1 The immunity levels of equipment shall be taken into account the electromagnetic influences (see Table 51-1) that can occur when connected and erected as for normal use, and taking into account the intended level of continuity of service necessary for the application.

51-5.3.1.2 Equipment shall be chosen with sufficiently low emission levels so that it cannot cause electromagnetic interference by electrical conduction or propagation in the air with other electrical equipment inside or outside the building. If necessary, means of mitigation shall be installed to minimize the emission (see Chapter 44).

Annex A.51
(Informative)

Concise List of External Influences

A *Environments*	*AA*	*Temperature (°C)*	*AF*	*Corrosion*	*AM*	*Radiation*
	AA1	−60 +5	AF1	Negligible	AM1	Negligible
	AA2	−40 +5	AF2	Atmospheric	AM2	Stray currents
	AA3	−25 +5	AF3	Intermittent	AM3	Electromagnetic
	AA4	−5 +40	AF4	Continuous	AM4	Ionization
	AA5	+5 +40	*AG*	*Impact*	AM5	Electrostatics
	AA6	+5 +60	AG1	Low	AM6	Induction
	AB	*Temperature and humidity*	AG2	Medium	*AN*	*Solar*
	AC	*Altitude (m)*	AG3	High	AN1	Low
	AC	≤ 2 000	*AH*	*Vibration*	AN2	Medium
	AC2	> 2 000	AH1	Low	AN3	High
	AD	*Water*	AH2	Medium	*AP*	*Seismic*
	AD1	Negligible	AH3	High	AP1	Negligible
	AD2	Drops	*AJ*	*Other mechanical stresses*	AP2	Low
	AD3	Spray	*AK*	*Flora*	AP3	Medium
	AD4	Splashes	AK1	No hazard	AP4	High
	AD5	Jets	AK2	Hazard	*AQ*	*Lightning*
	AD6	Waves	*AL*	*Fauna*	AQ1	Negligible
	AD7	Immersion	AL1	No hazard	AQ2	Indirect
	AD8	Submersion	AL2	Hazard	AQ3	Direct
	AE	*Foreign bodies*			*AR*	*Movement of air*
	AE1	Negligible			AR1	Low
	AE2	Small			AR2	Medium
	AE3	Very small			AR3	High
	AE4	Light dust			*AS*	*Wind*
	AE5	Moderate dust			AS1	Low
	AE6	Heavy dust			AS2	medium
					AS3	High
B *Utilization*	*BA*	*Capability*	*BD*	*Evacuation*	*BE*	*Materials*
	BA1	Ordinary	BD1	Normal	BE1	No risk
	BA2	Children	BD2	Difficult	BE2	Fire risk
	BA3	Handicapped	BD3	Crowded	BE3	Explosion risk
	BA4	Instructed	BD4	Difficult and crowded	BE4	Contamination risk
	BA5	Skilled				
	BB	*Resistance*				
	BC	*Contact with earth*				
	BC1	None				
	BC2	Low				
	BC3	Frequent				
	BC4	Continuous				
C *Buildings*	*CA*	*Materials*	*CB*	*Structure*		
	CA1	Non-combustible	CB1	Negligible		
	CA2	Combustible	CB2	Fire propagation		
			CB3	Structure movement		
			CB4	Flexible		

Annex B.51
(informative)

Interdependence of Air Temperature, Relative Air Humidity and Absolute Air Humidity

This annex contains climatograms for each class of ambient climatic conditions, showing the interdependence of air temperature, relative air humidity and absolute air humidity by curves for constant absolute humidity and lines for temperature and relative humidity.

As far as air temperature is concerned, the climatogram shows the possible maximum temperature difference for any location covered by the class.

As far as air humidity is concerned, the climatogram comprises the complete scatter of values of relative air humidity in accordance with any air temperature occurring within the range covered by the class. The interdependence of both temperature and humidity is fixed by the values of absolute air humidity occurring within the range of the class.

As already stated in the notes of Table 51-1, the limit values of, for example, high air temperature and high relative air humidity given in the classes will normally not occur in combination. Normally higher values of air temperature will occur combined with lower values of relative air humidity.

Exceptions from this rule will be found for classes AB1, AB2 and AB3, where any value of relative humidity specified for the range may be combined with the highest value of air temperature. This fact should be considered in connection with the rather low value of high absolute humidity for the limit value of high air temperature in these classes.

To give a review of this situation, in the following table for each class the highest value of air temperature, which may occur is given together with the highest value of relative air humidity of the class. At air temperatures higher than the value given in the table the relative air humidity will be lower, i.e. below the limit value of the class.

Class code	Limit value of relative air humidity	Highest value of air temperature to occur with limit value of relative air humidity
AB1	100 %	+5°C
AB2	100 %	+5°C
AB3	100 %	+5°C
AB4	95 %	+31°C
AB5	85 %	+28°C
AB6	100 %	+33°C
AB7	100 %	+27°C
AB8	100 %	+33°C

In practice, the climatograms may be used as follows:

The relevant value of relative air humidity at a certain value of air temperature within the temperature range of a class may be found at the point where the curve for constant absolute air humidity cuts the straight lines for air temperature and relative air humidity respectively.

Example:

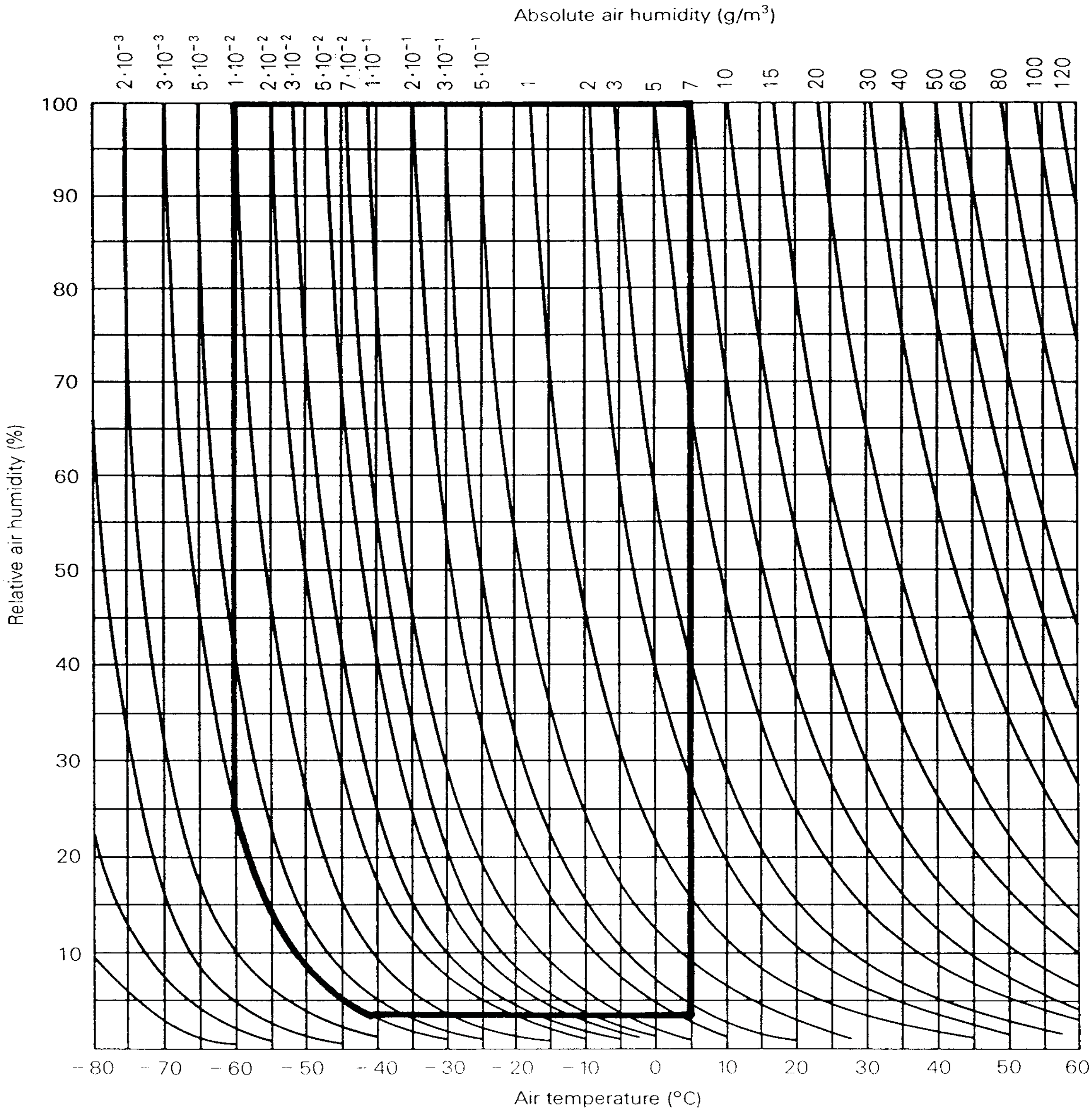
A product may be selected for installation conditions covered by class AB6. To find out which relative air humidity the product will have to withstand in the utmost at, for example, 40°C, one follows the vertical line for air temperature 40°C in the climatogram for class AB6 up to the point where it meets the curve for 35 g/m^3 absolute air humidity which is the limit value for high absolute air humidity for this class. From this point one draws a horizontal line to the scale of relative air humidity, and one will find a value of 67 % relative air humidity.

Using this method, any other possible combination of air temperature and relative air humidity within the range of the class may be found, for example, in class AB6 a value of 27 % relative air humidity will be found at the limit value of high air temperature which is 60°C.

Climatogram

Interdependence of air temperature, relative air humidity and absolute air humidity.

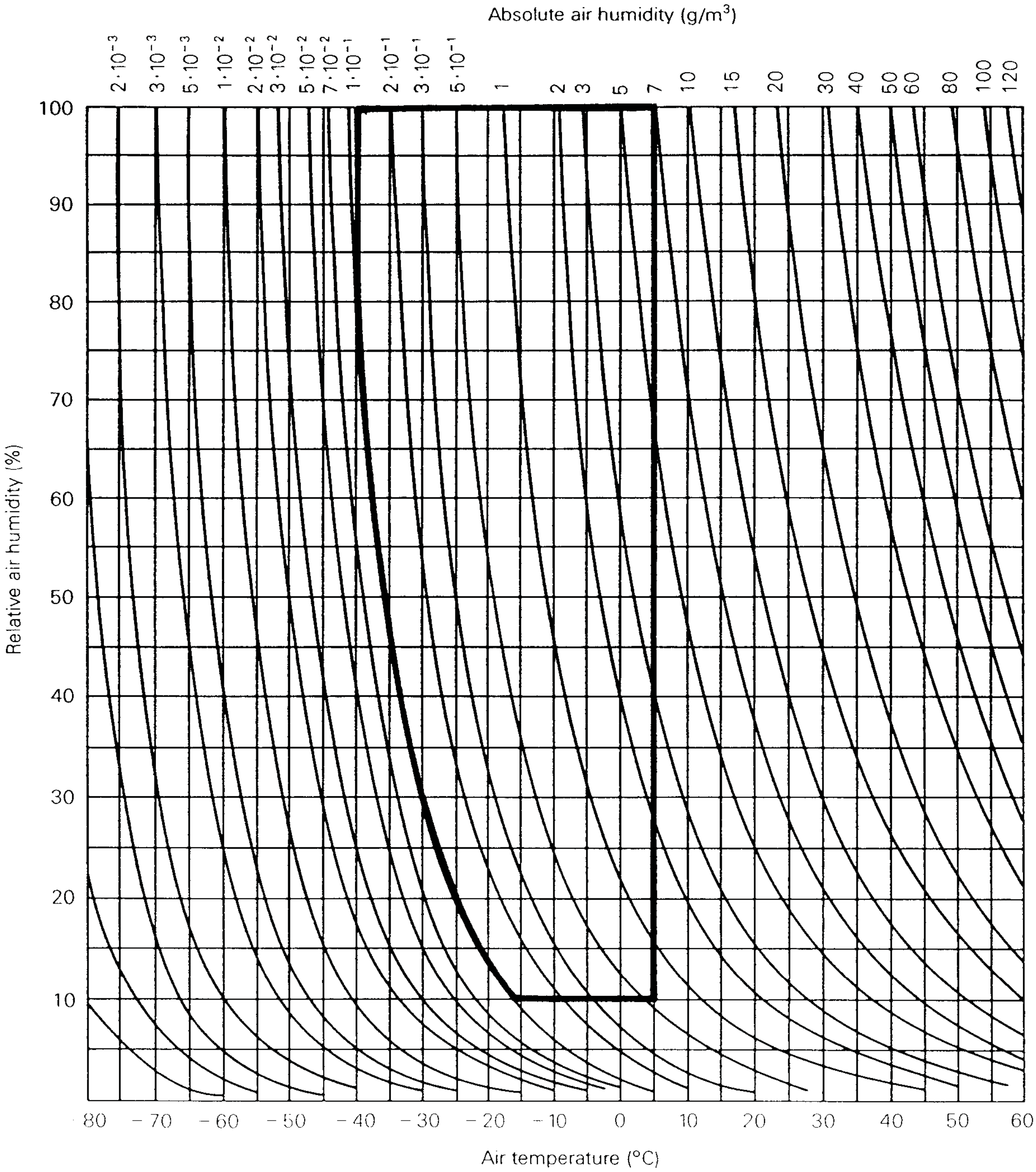
Class AB 1



Climatogram

Interdependence of air temperature, relative air humidity and absolute air humidity.

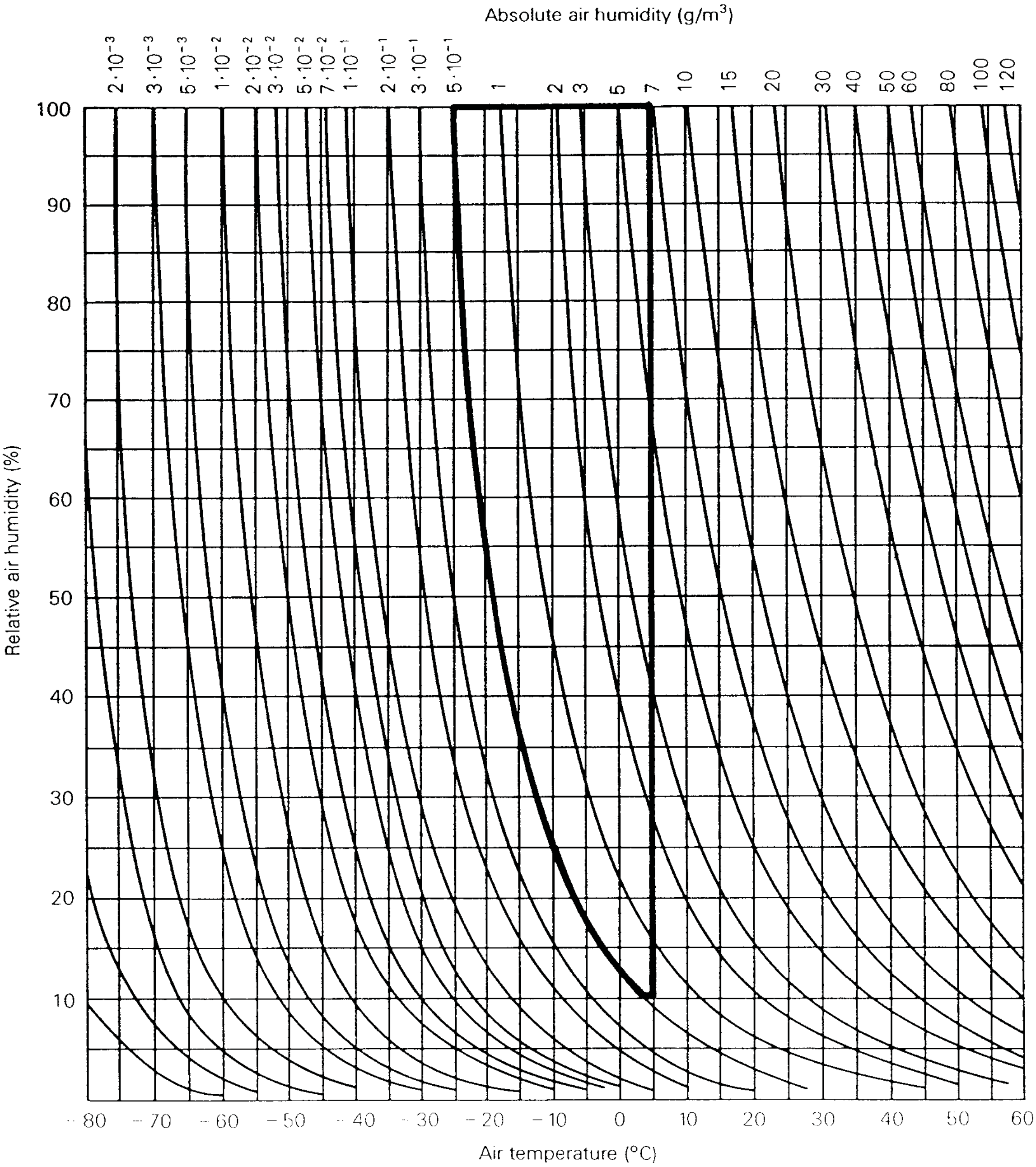
Class AB 2



Climatogram

Interdependence of air temperature, relative air humidity and absolute air humidity.

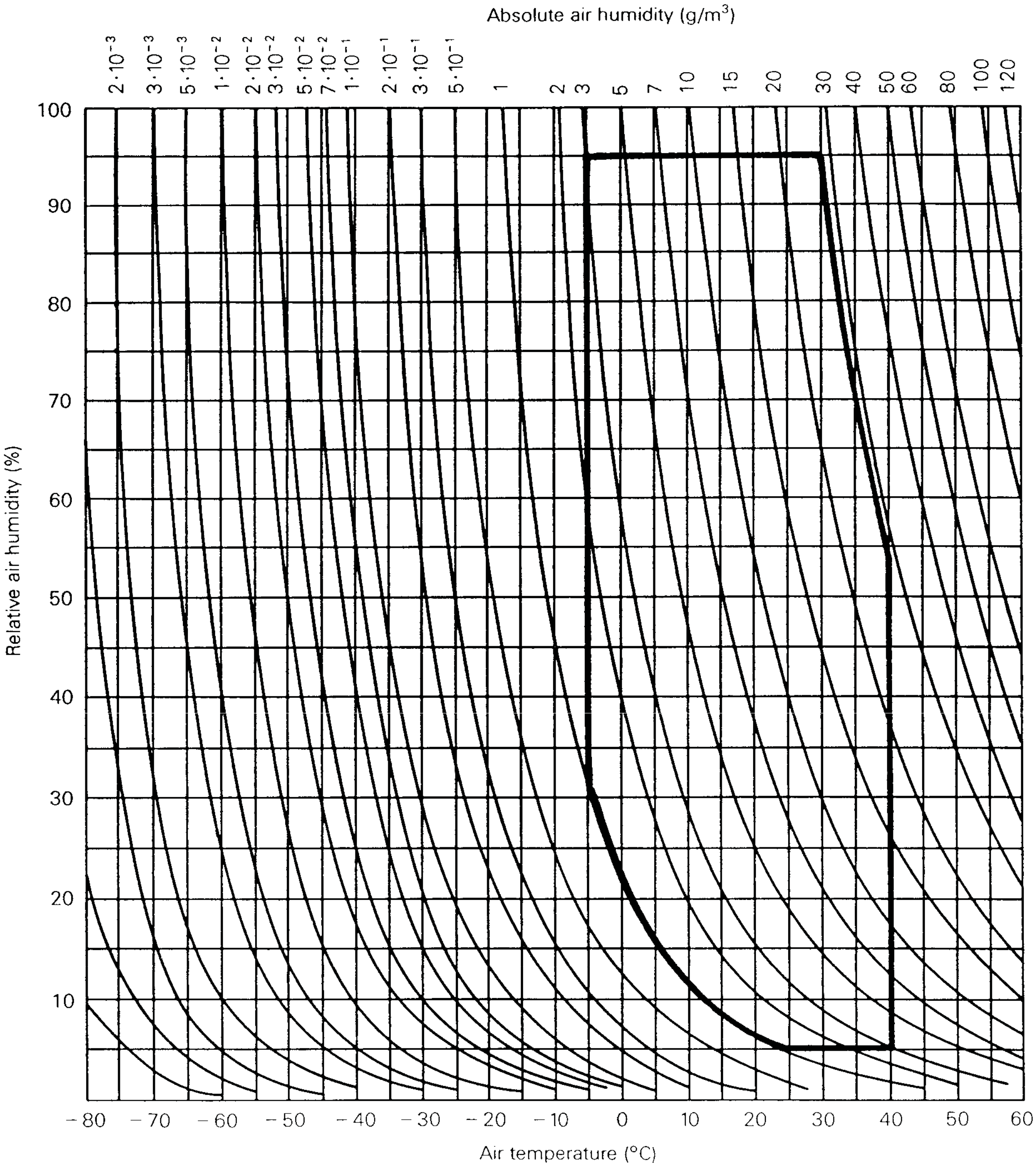
Class AB 3



Climatogram

Interdependence of air temperature, relative air humidity and absolute air humidity.

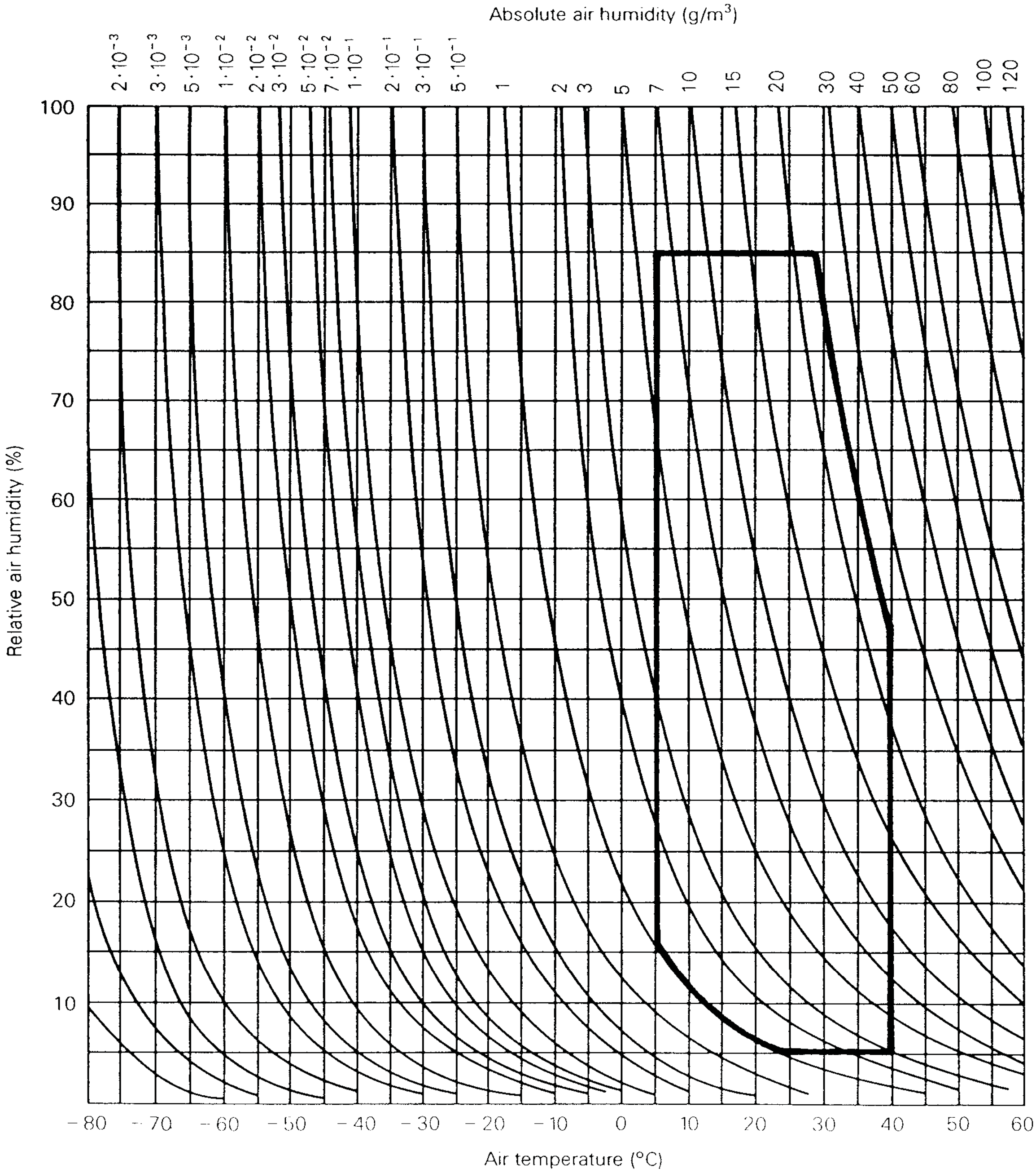
Class AB 4



Climatogram

Interdependence of air temperature, relative air humidity and absolute air humidity.

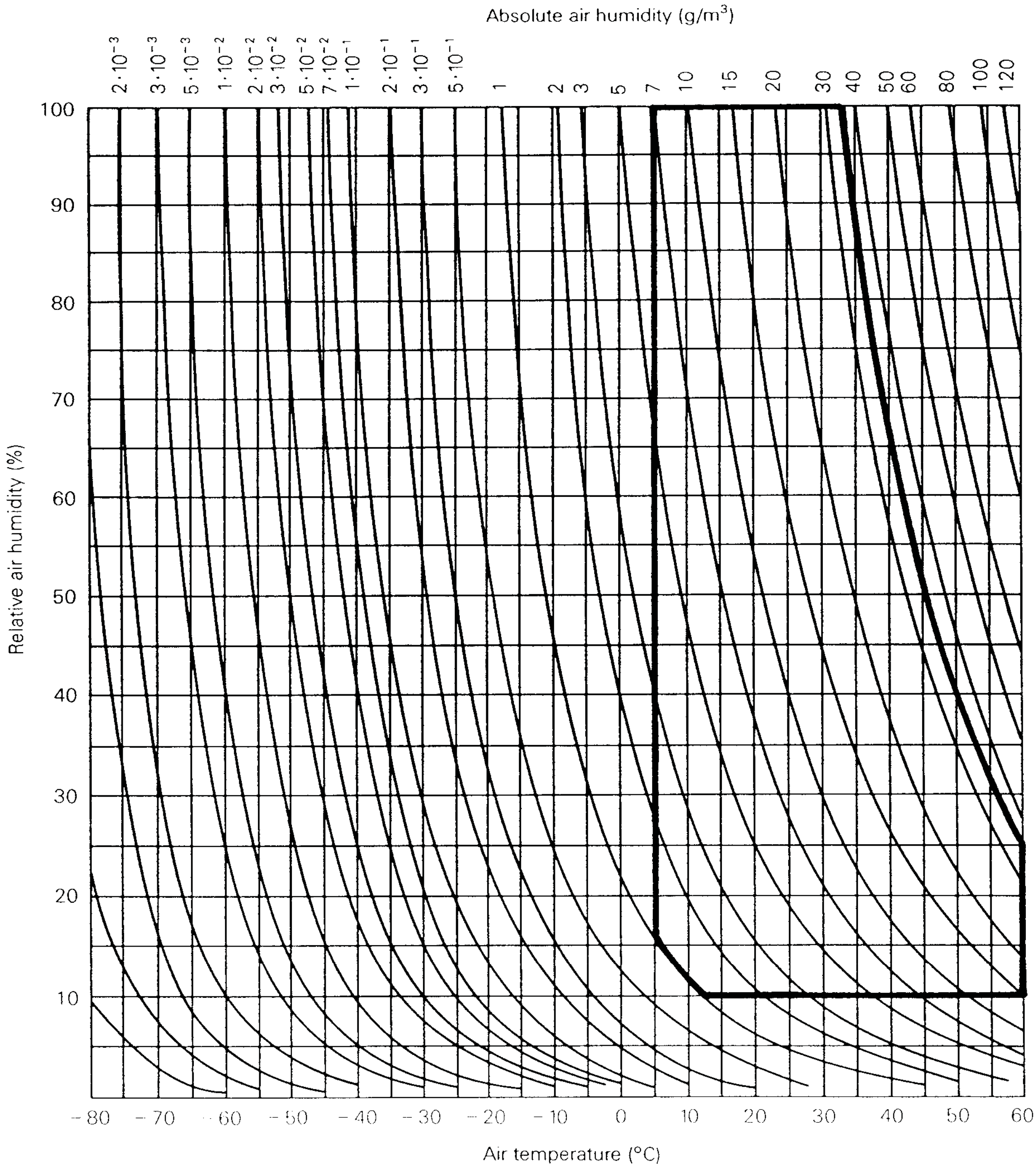
Class AB 5



Climatogram

Interdependence of air temperature, relative air humidity and absolute air humidity.

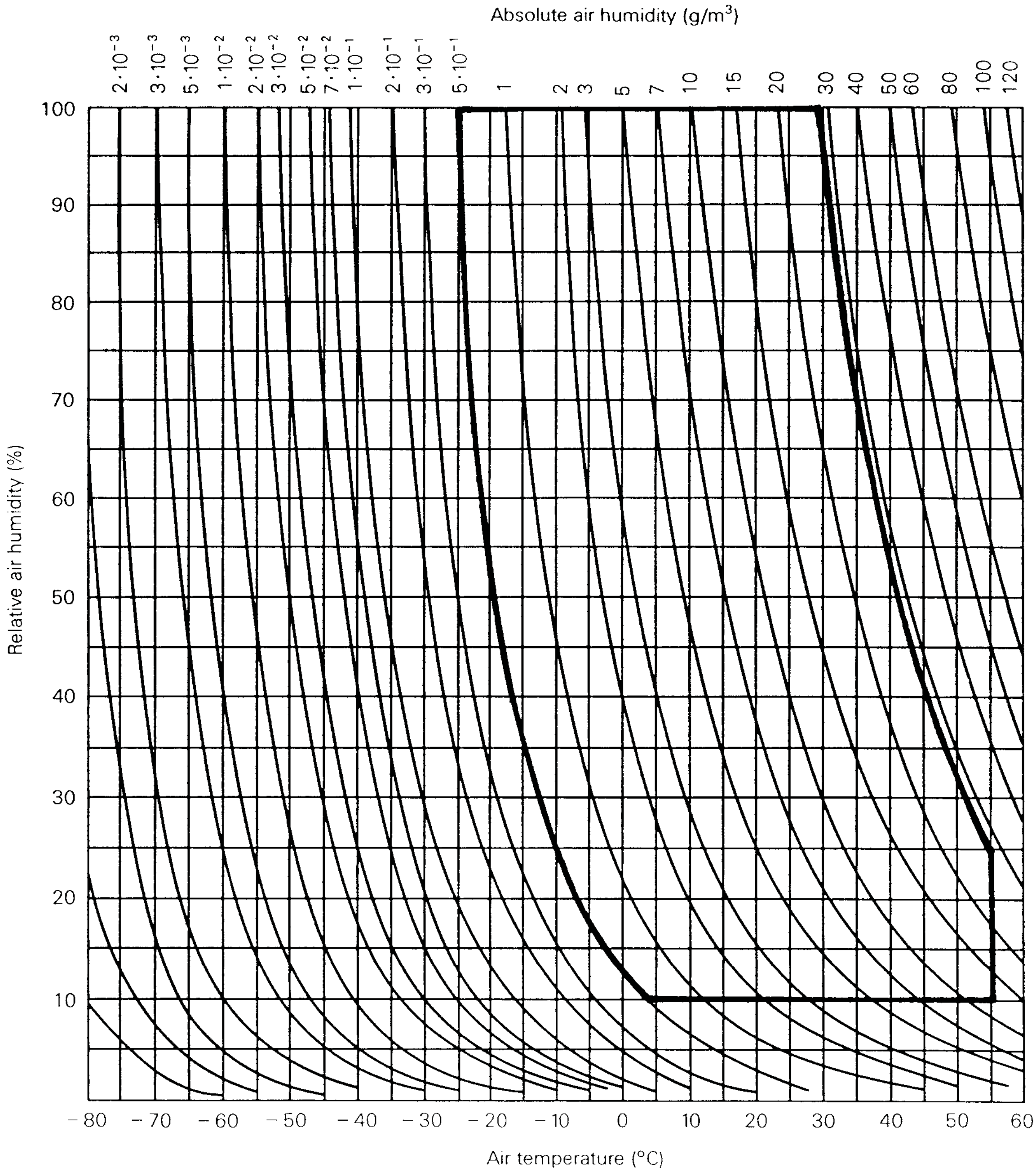
Class AB 6



Climatogram

Interdependence of air temperature, relative air humidity and absolute air humidity.

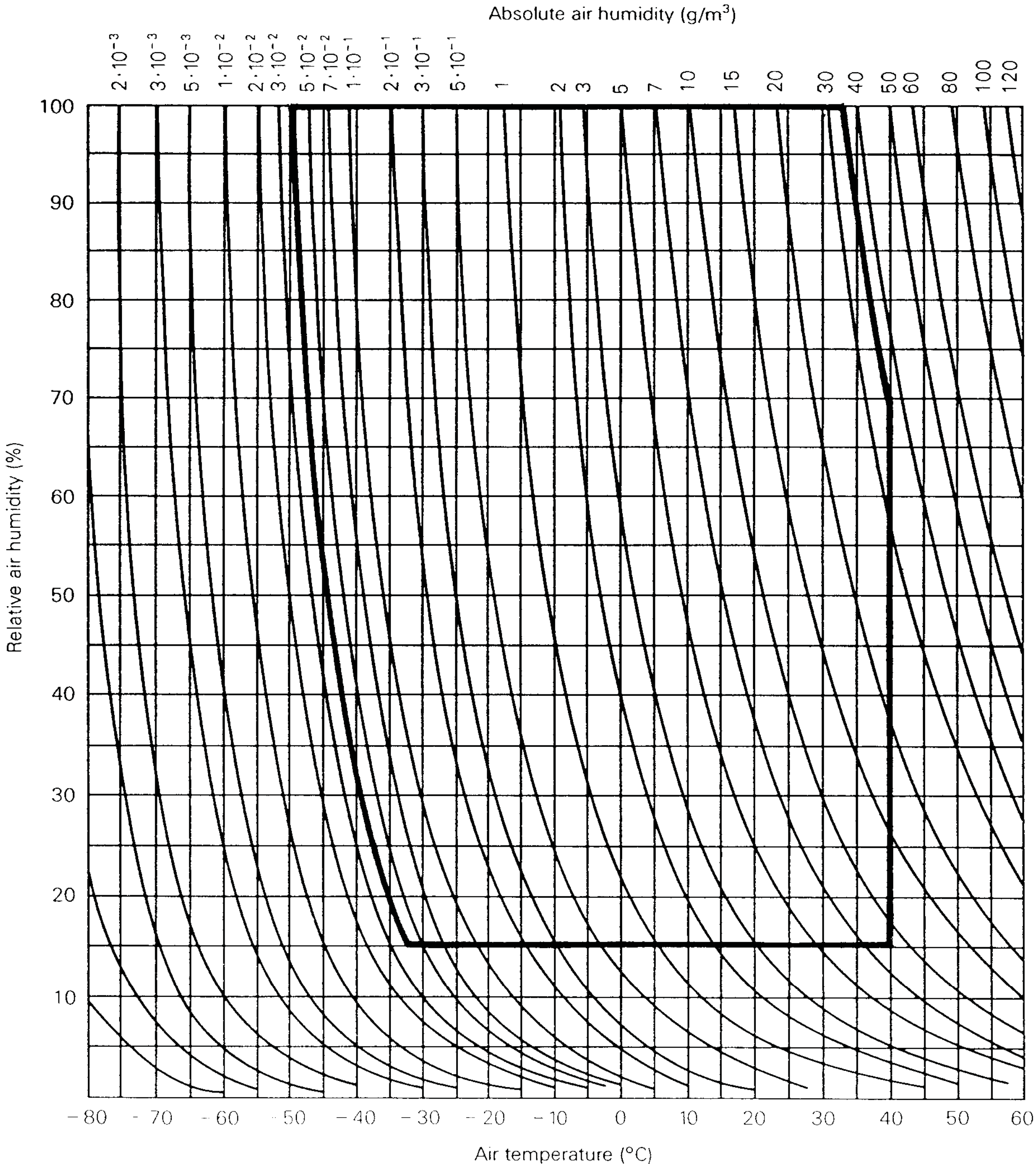
Class AB 7



Climatogram

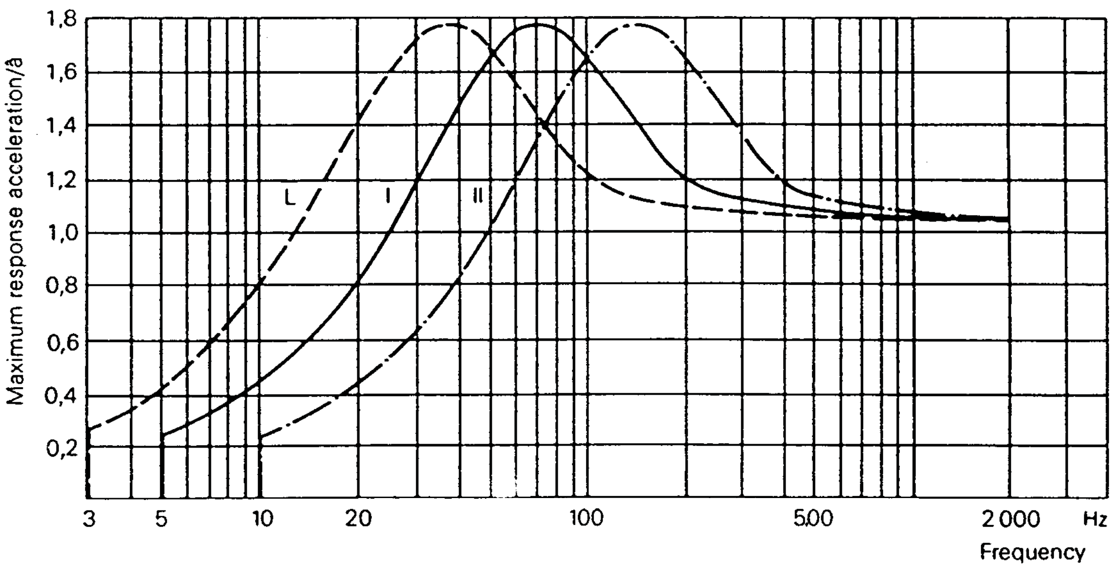
Interdependence of air temperature, relative air humidity and absolute air humidity.

Class AB 8



Annex C.51
(normative)
Classification of Mechanical Conditions

Environmental parameter	Unit	Class															
		AG1/AH1						AG2/AH2				AG3/AH3					
		3M1 4M1		3M2 4M2		3M3 4M3		3M4 4M4		3M5 4M5		3M6 4M6		3M7 4M7		3M8 4M8	
Stationary vibration, sinusoidal																	
Displacement amplitude	mm	0.3		1.5		1.5		3.0		3.0		7.0		10		15	
Acceleration amplitude	m/s²		1		5		5		10		10		20		30		50
Frequency range	Hz	2-9	9-200	2-9	9-200	2-9	9-200	2-9	9-200	2-9	9-200	2-9	9-200	2-9	9-200	2-9	9-200
Non-stationary vibration, including shock																	
Shock response spectrum type L (â)	m/s²	40		40		70		–		–		–		–		–	
Shock response spectrum type I (â)	m/s²	–		–		–		100		–		–		–		–	
Shock response spectrum type II (â)	m/s²	–		–		–		–		250		250		250		250	
NOTE â = maximum acceleration.																	



Spectrum type L Duration =22 ms
Spectrum type I Duration =11 ms
Spectrum type II Duration= 6 ms

Figure C.51-1 Model shock response spectra
(first order "maximas" shock response spectra)

Annex D.51
(normative)

Classification of Macro-Environments

Category of environment	Climatic conditions	Chemically and mechanically active substances [a]
I	AB 5 3K 3	AF 2/AE 1 3C 2/3S 1
II	AB 4 3K 5, but the high air temperature is restricted to +40°C	AF 1/AE 4 3C 1/3S 2
III	AB 7 3K 6	AF 2/AE 5 3C 2/3S 3
IV	AB 8 4K 3	AF 3/AE 6 3C 3/3S 4

[a] The first line in each box shows the class designation according to table 51-1.
The second line shows the class designation according to SASO IEC 60721-3-0.

NOTE The macro-environment is the environment of the room or other location in which the equipment is installed or used.

Annex E.51
(normative)

Working Space

Table E.51-1 Depth of Working Space

Nominal Voltage	Minimum Clear Distance		
	Condition 1	Condition 2	Condition 3
220 V–600 V	900 mm	1 m	1.2 m

Condition 1 — Exposed live parts on one side and no live or earthed parts on the other side of the working space, or exposed live parts on both sides effectively guarded by suitable wood or other insulating materials.
Condition 2 — Exposed live parts on one side and earthed parts on the other side. Concrete, brick, or tile walls shall be considered as earthed.
Condition 3 — Exposed live parts on both sides of the work space (not guarded as provided in Condition 1) with the operator between.

Width of Working Space: The width of the working space in front of the electric equipment shall be the width of the equipment or 750 mm, which ever is greater.

Height of Working Space: The work space shall be clear and extend from the grade, floor, or platform to the height required The minimum headroom of working spaces about service equipment, switchboards, panelboards, or motor control centers shall be 2.0 m. Where the electrical equipment exceeds 2.0 m in height, the minimum headroom shall not be less than the height of the equipment.

Clear Spaces. Working space required by this section shall not be used for storage. When normally enclosed live parts are exposed for inspection or servicing, the working space, if in a passageway or general open space shall be suitably guarded.

Entrance to Working Space: At least one entrance of sufficient area shall be provided to give access to working space about electrical equipment.

Dedicated Equipment Space: All switchboards, panelboards, distribution boards, and motor control centers shall be located in dedicated spaces and protected from damage.

Outdoor: Outdoor electrical equipment shall be installed in suitable enclosures and shall be protected from accidental contact by unauthorized personnel, or by vehicular traffic, or by accidental spillage or leakage from piping systems.

CHAPTER 52
WIRING SYSTEMS

52-0.1 Scope

This chapter deals with the selection and erection of wiring systems.

NOTE This chapter also applies in general to protective conductors, while Chapter 54 contains further requirements for those conductors.

52-0.2 General

Consideration shall be given to the application of the fundamental principles of Chapter 12 as it applies to cables and conductors, to their termination and/or jointing, to their associated supports or suspensions and their enclosures or methods of protection against external influences.

52-1 Types of wiring systems

52-1.1 The method of installation of a wiring system in relation to the type of conductor or cable used shall be in accordance with Table 52-1, provided the external influences are covered by the requirements of the relevant product standards.

52-1.2 The method of installation of a wiring system in relation to the situation concerned shall be in accordance with Table 52-2.

52-1.3 Examples of wiring systems together with reference to the appropriate table of current-carrying capacity are shown in Table 52-3.

NOTE 1 Other type of wiring systems, not covered in this chapter, may be used provided they comply with the general rules of this chapter.

NOTE 2 Table 52-3 gives the reference method of installation where it is considered that the same current- carrying capacities can safely be used.

52-1.4 Busbar trunking systems

Busbar trunking systems shall comply with SASO 1610 and shall be installed in accordance with the manufacturer's instructions. The installation shall be in accordance with the requirements of Sections 52-2 (with the exception of 52-2.1.1, 52-2.3.3, 52-2.8.7, 52-2.8.8 and 52-2.8.9), 52-5, 52-6, 52-7 and 52-8.

52-1.5 AC circuits

Conductors of a.c. circuits installed in ferromagnetic enclosures shall be arranged so that all conductors of each circuit are contained in the same enclosure.

NOTE If this condition is not fulfilled, overheating and excessive voltage drop may occur due to inductive effects.

Table 52-1 Selection of wiring systems

Conductors and cables		Method of installation							
		Without fixings	Clipped direct	Conduit	Cable trunking (including skirting trunking, flush floor trunking)	Cable ducting	Cable ladder Cable tray Cable brackets	On insulators	Support wire
Bare conductors		–	–	–	–	–	–	+	–
Insulated conductors		–	–	+	+	+	–	+	–
Sheathed cables (including armoured and mineral insulated)	Multi-core	+	+	+	+	+	+	0	+
	Single-core	0	+	+	+	+	+	0	+

\+ Permitted.

– Not permitted.

0 Not applicable, or not normally used in practice.

Table 52-2 Erection of wiring systems

Situations	Method of installation							
	Without fixings	With fixings	Conduit	Cable trunking (including skirting trunking, flush floor trunking)	Cable ducting	Cable ladder, cable tray, cable brackets	On insulators	Support wire
Building voids	40, 46, 15, 16	0	15,16, 41,42	–	43	30, 31, 32, 33, 34	–	–
Cable channel	56	56	54, 55	0	44, 45	30, 31, 32, 33, 34	–	–
Buried in earth	72, 73	0	70, 71	–	70, 71	0	–	–
Embedded in structure	57, 58	3	1.2, 59, 60	50, 51, 52, 53	44, 45	0	–	–
Surface mounted	–	20, 21, 22, 23	4.5	6, 7, 8, 9, 12, 13, 14	6, 7, 8, 9	30, 31, 32, 33, 34	36	–
Overhead	–	–	0	10, 11	–	30, 31, 32, 33, 34	36	35
Immersed	80	80	0	–	0	0	–	–

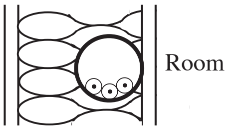
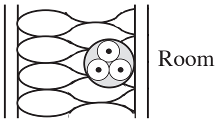
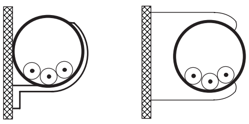
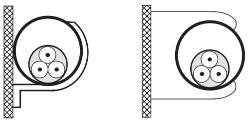
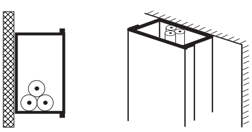
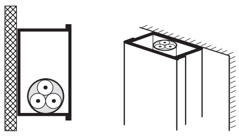
The number in each box indicates the item number in table 52-3.

– Not permitted.

0 Not applicable or not normally used in practice.

Table 52-3 Examples of methods of installation providing instructions for obtaining current-carrying capacity

NOTE The illustrations are not intended to depict actual product or installation practices but are indicative of the method described.

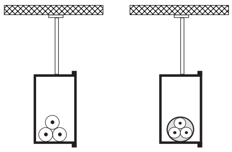
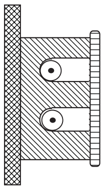
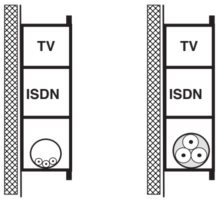
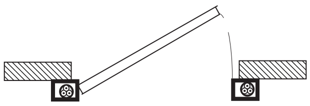
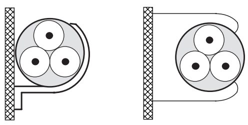
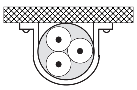
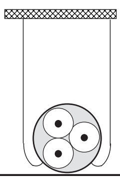
Item No.	Methods of installation	Description	Reference method of installation to be used to obtain current-carrying capacity (see annex A.52)
1		Insulated conductors or single-core cables in conduit in a thermally insulated wall [a]	A1
2		Multi-core cables in conduit in a thermally insulated wall [a]	A2
3		Multi-core cable direct in a thermally insulated wall [a]	A1
4		Insulated conductors or single-core cables in conduit on a wooden, or masonry wall or spaced less than 0.3 × conduit diameter from it	B1
5		Multi-core cable in conduit on a wooden, or masonry wall or spaced less than 0.3 × conduit diameter from it	B2
6 7	 6 7	Insulated conductors or single-core cables in cable trunking on a wooden wall – run horizontally [b] – run vertically [b, c]	B1
8 9	 8 9	Multi-core cable in cable trunking on a wooden wall – run horizontally [b] – run vertically [b, c]	B2

[a] The inner skin of the wall has a thermal conductance of not less than 10 $W/m^2 \cdot K$.

[b] Values given for installation methods B1 and B2 in annex A are for a single circuit. Where there is more than one circuit in the trunking the group reduction factor given in table A.52-17 is applicable, irrespective of the presence of an internal barrier or partition.

[c] Care shall be taken where the cable runs vertically and ventilation is restricted. The ambient temperature at the top of the vertical section can be increased considerably. The matter is under consideration.

Table 52-3 *(continued)*

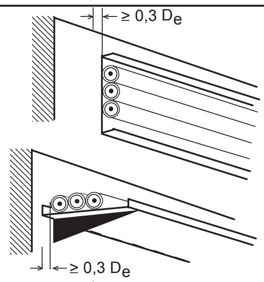
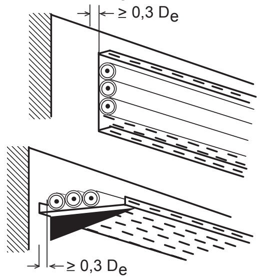
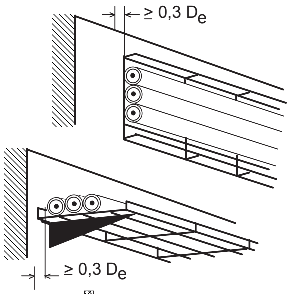
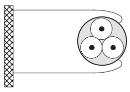
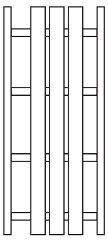
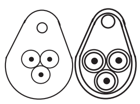
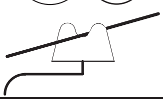
Item No.	Methods of installation	Description	Reference method of installation to be used to obtain current-carrying capacity (see annex A.52)
10	 10 11	Insulated conductors or single-core cable in suspended cable trunking [a]	B1
11		Multi-core cable in suspended cable trunking [a]	B2
12		Insulated conductors or single-core cable run in mouldings [b]	A1
13	 13 14	Insulated conductors or single-core cables in skirting trunking	B1
14		Multi-core cable in skirting trunking	B2
15		Insulated conductors in conduit or single-core or multi-core cable in architrave [c]	A1
16		Insulated conductors in conduit or single-core or multi-core cable in window frames [c]	A1
20		Single-core or multi-core cables: – fixed on, or spaced less than 0.3 × cable diameter from a wooden wall	C
21		– fixed directly under a wooden ceiling	C, with item 3 of table A.52-17
22		– spaced from a ceiling	Under consideration

[a] Values given for installation methods B1 and B2 in annex A are for a single circuit. Where there is more than one circuit in the trunking the group reduction factor given in Table A.52-17 is applicable, irrespective of the presence of an internal barrier or partition.

[b] The thermal resistivity of the enclosure is assumed to be poor because of the material of construction and possible air spaces. Where the construction is thermally equivalent to methods of installation 6 or 7, reference method B1 may be used.

[c] The thermal resistivity of the enclosure is assumed to be poor because of the material of construction and possible air spaces. Where the construction is thermally equivalent to methods of installation 6, 7, 8, or 9, reference methods B1 or B2 may be used.

Table 52-3 *(continued)*

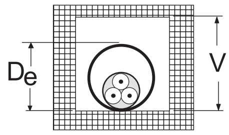
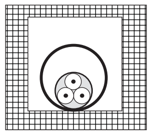
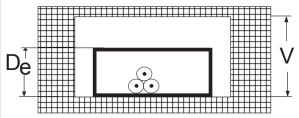
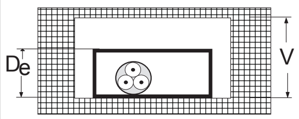
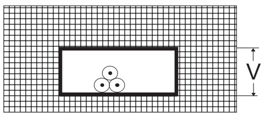
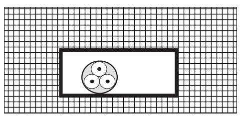
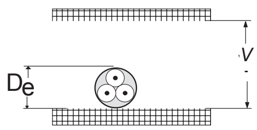
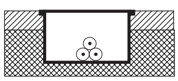
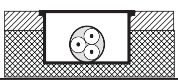
Item No.	Methods of installation	Description	Reference method of installation to be used to obtain current-carrying capacity (see annex A.52)
30		On imperforated tray [c]	C with item 2 of table A.52-17 [a]
31		On perforated tray [c]	E or F with item 4 of table A.52-17 [a, b]
32		On brackets or on a wire mesh [c]	E or F
33		Spaced more than 0.3 times cable diameter from a wall	E or F with item 4 or 5 of table A.52-17 or method G [a, b]
34		On ladder	E or F
35		Single-core or multi-core cable suspended from or incorporating a support wire	E or F
36		Bare or insulated conductors on insulators	G

[a] For certain applications it may be more appropriate to use specific factors, for example Tables A.52-20 and A.52-21 (see A.52.4.2 of Annex A.52).

[b] Care shall be taken where the cable runs vertically and ventilation is restricted. The ambient temperature at the top of the vertical section can be increased considerably. The matter is under consideration.

[c] D_e = the external diameter of a multi-core cable:
- 2.2 x the cable diameter when three single core cables are bound in trefoil, or
- 3 x the cable diameter when three single core cables are laid in flat formation.

Table 52-3 *(continued)*

Item No.	Methods of installation	Description	Reference method of installation to be used to obtain current-carrying capacity (see annex A.52)
40		Single-core or multi-core cable in a building void [a]	$1.5\ D_e \leq V < 20\ D_e$ B2 $V \geq 20\ D_e$ B1
42		Single-core or multi-core cable in conduit in a building void [d]	Under consideration
24		Insulated conductors in cable ducting in a building void [a, c, d]	$1.5\ D_e \leq V < 20\ D_e$ B2 $V \geq 20\ D_e$ B1
43		Single-core or multi-core cable in cable ducting in a building void [d]	Under consideration
44		Insulated conductors in cable ducting in masonry having a thermal resistivity not greater than 2 K · m/W [a, b, d]	$1.5\ D_e \leq V < 5\ D_e$ B2 $5\ D_e \leq V < 50\ D_e$ B1
45		Single-core or multi-core cable in cable ducting in masonry having a thermal resistivity not greater than 2 K · m/W [d]	Under consideration
46		Single-core or multi-core cable: – in a ceiling void – in a suspended floor [a, b]	$1.5\ D_e \leq V < 5\ D_e$ B2 $5\ D_e \leq V < 50\ D_e$ B1
50		Insulated conductors or single-core cable in flush cable trunking in the floor	B1
51		Multi-core cable in flush cable trunking in the floor	B2

[a] V = the smaller dimension or diameter of a masonry duct or void, or the vertical depth of a rectangular duct, floor or ceiling void.

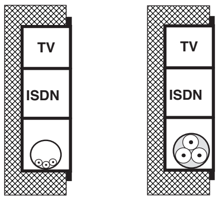
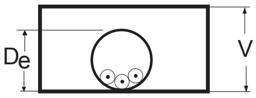
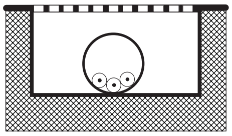
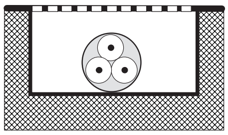
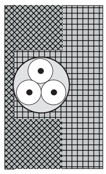
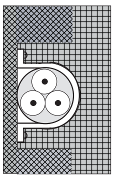
[b] D_e = the external diameter of a multi-core cable:

- 2.2 x the cable diameter when three single core cables are bound in trefoil, or
- 3 x the cable diameter when three single core cables are laid in flat formation.

[c] D_e = external diameter of conduit or vertical depth of cable ducting.

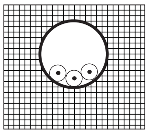
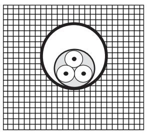
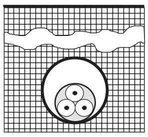
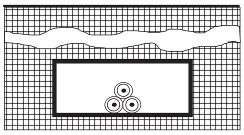
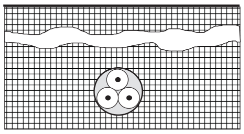
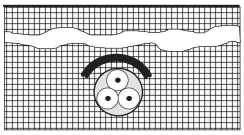
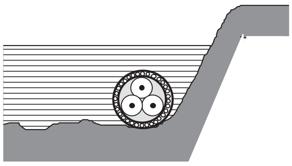
[d] Care shall be taken where the cable runs vertically and ventilation is restricted. The ambient temperature at the top of the vertical section can be increased considerably. The matter is under consideration.

Table 52-3 *(continued)*

Item No.	Methods of installation	Description	Reference method of installation to be used to obtain current-carrying capacity (see annex A.52)
52	 52 53	Insulated conductors or single-core cables in embedded trunking	B1
53		Multi-core cable in embedded trunking	B2
54		Insulated conductors or single-core cables in conduit in an unventilated cable channel run horizontally or vertically [a, b]	$1.5\ D_e \leq V < 20\ D_e$ B2 $V \geq 20\ D_e$ B1
55		Insulated conductors in conduit in an open or ventilated cable channel in the floor [c, d]	B1
56		Sheathed single-core or multi-core cable in an open or ventilated cable channel run horizontally or vertically [d]	B1
57		Single-core or multi-core cable direct in masonry having a thermal resistivity not greater than 2 K · m/W Without added mechanical protection [e, f]	C
58		Single-core or multi-core cable direct in masonry having a thermal resistivity not greater than 2 K · m/W With added mechanical protection [e, f]	C

[a] *De* = external diameter of conduit
V = internal depth of the channel
The depth of the channel is more important than the width.
[b] Care shall be taken where the cable runs vertically and ventilation is restricted. The ambient temperature at the top of the vertical section can be increased considerably. The matter is under consideration.
[c] For multi-core cable installed in method 55, use ratings for reference method B2.
[d] It is recommended that these methods of installation are used only in areas where access is restricted to authorised persons so that the reduction in current-carrying capacity and the fire hazard due to the accumulation of debris can be prevented.
[e] For cables having conductors not greater than 16 mm^2, the current-carrying capacity may be higher.
[f] Thermal resistivity of masonry is not greater than 2 K · m/W.

Table 52-3 *(continued)*

Item No.	Methods of installation	Description	Reference method of installation to be used to obtain current-carrying capacity (see annex A.52)
59		Insulated conductors or single-core Cables in conduit in masonry[a]	B1
60		Multi-core cables in conduit in masonry[a]	B2
70		Multi-core cable in conduit or in cable ducting in the earth	D
71		Single-core cable in conduit or in cable ducting in the earth	D
72		Sheathed single-core or multi-core cables direct in the earth – without added mechanical protection (see note)	D
73		Sheathed single-core or multi-core cables direct in the earth – with added mechanical protection (see note)	D
80		Sheathed single-core or multi-core cables immersed in water	Under consideration

NOTE The inclusion of directly buried cables in this item is satisfactory when the soil thermal resistivity is of the order of 2.5 K · m/W. For lower soil resistivities, the current-carrying capacity for directly buried cables is appreciably higher than for cables in ducts.

[a] Thermal resistivity of masonry is not greater than 2 K · m/W.

52-1.6 Conduits and trunking systems

Several circuits are allowed in the same conduit or trunking provided all conductors are insulated for the highest nominal voltage present.

52-2 Selection and erection of wiring systems in relation to external influences

NOTE The external influences categorized in table A.51-1 of Chapter 51, which are of significance to wiring systems are included in this section.

52-2.1 Ambient temperature (AA)

52-2.1.1 Wiring systems shall be selected and erected so as to be suitable for the highest local ambient temperature and to ensure that the limiting temperature indicated in Table 52-4 will not be exceeded.

NOTE For local ambient temperature refer to Energy Conservation Requirements.

52-2.1.2 Wiring system components including cables and wiring accessories shall only be installed or handled at temperatures within the limits stated in the relevant product specification or as given by the manufacturers.

52-2.2 External heat sources

52-2.2.1 In order to avoid the effects of heat from external sources, one of the following methods or an equally effective method shall be used to protect wiring systems:

- shielding;
- placing sufficiently far from the source of heat;
- selecting a system with due regard for the additional temperature rise which may occur;
- local reinforcement or substitution of insulating material;

NOTE Heat from external sources may be radiated, convicted or conducted, e.g.

- from hot water systems;
- from plant appliances and luminaries;
- from manufacturing process;
- through heat conducting materials;
- from solar gain of the wiring system or its surrounding medium.

52-2.3 Presence of water (AD)

52-2.3.1 Wiring systems shall be selected and erected so that no damage is caused by the ingress of water. The completed wiring system shall comply with the IP degree of protection relevant to the particular location.

NOTE In general, the sheaths and insulation of cables for fixed installations may be regarded, when intact, as proof against penetration by moisture. Special considerations apply to cables liable to frequent splashing, immersion or submersion.

52-2.3.2 Where water may collect or condensation may form in wiring systems, provision shall be made for its escape.

52-2.3.3 Where wiring systems may be subjected to waves (AD6), protection against mechanical damage shall be afforded by one or more of the methods of 52-2.6, 52-2.7 and 52-2.8.

52-2.4 Presence of solid foreign bodies (AE)

52-2.4.1 Wiring systems shall be selected and erected so as to minimize the danger arising from the ingress of solid foreign bodies. The completed wiring system shall comply with the IP degree of protection relevant to the particular location.

52-2.4.2 In a location where dust in significant quantity is present (AE4), additional precautions shall be taken to prevent the accumulation of dust or other substances in quantities, which could adversely affect the heat dissipation from the wiring system.

NOTE A wiring system, which facilitates the removal of dust, may be necessary (see 52-9).

52-2.5 Presence of corrosive or polluting substances (AF)

52-2.5.1 Where the presence of corrosive or polluting substances, including water, is likely to give rise to corrosion or deterioration, parts of the wiring system likely to be affected shall be suitably protected or manufactured from a material resistant to such substances.

NOTE Suitable protection for application during erection may include protective tapes, paints or grease.

52-2.5.2 Dissimilar metals liable to initiate electrolytic action shall not be placed in contact with each other, unless special arrangements are made to avoid the consequences of such contacts.

52-2.5.3 Materials liable to cause mutual or individual deterioration or hazardous degradation shall not be placed in contact with each other.

52-2.6 Impact (AG)

52-2.6.1 Wiring systems shall be selected and erected so as to minimize the damage arising from mechanical stress, e.g. by impact, penetration or compression.

52-2.6.2 In fixed installations where impacts of medium severity (AG2) or high severity (AG3) can occur, protection shall be afforded by:

- the mechanical characteristics of the wiring system; or
- the location selected; or
- the provision of additional local or general mechanical protection; or
- by any combination of the above.

52-2.7 Vibration (AH)

52-2.7.1 Wiring systems supported by or fixed to structures of equipment subject to vibration of medium severity (AH2) or high severity (AH3) shall be suitable for such conditions, particularly where cables and cable connections are concerned.

NOTE Special attention should be paid to connections to vibrating equipment (such as motors and generator).

52-2.7.2 Fixed installation of suspended current-using equipment, e.g. luminaires, shall be connected by cable with flexible core. Where no vibration nor movement can be expected, cable with non-flexible core may be used.

52-2.8 Other mechanical stresses (AJ)

52-2.8.1 Wiring systems shall be selected and erected so as to prevent during installation, use or maintenance, damage to the sheath and insulation of cables and insulated conductors and their terminations.

52-2.8.2 When buried in the structure, conduits or cable ducting systems shall be completely erected for each circuit before any insulated conductor or cable is drawn in.

NOTE Flexible wiring systems may be used. Proper means of protection is required to avoid wires from sharp edges when wire passes through opening of any metallic enclosures.

52-2.8.3 The radius of every bend in a wiring system shall be such that conductors or cables shall not suffer damage.

NOTE The conductor is recommended to be bent to a radius less than 8 times the overall diameter for nonshielded conductors or 12 times the diameter the diameter for shielded or lead-covered conductors during or after installation. For multiconductor or multiplexed single conductor cables having individually shielded conductors, the minimum bending radius is 12 times the diameter of the individual shielded conductors or 7 times the overall diameter, whichever is greater or according to manufacturer procedures.

52-2.8.4 Where the conductors or cables are not supported continuously due to the method of the installation, they shall be supported by suitable means at appropriate intervals in such a manner that the conductors or cables do not suffer damage by their own weight.

52-2.8.5 Where a permanent tensile stress is applied to the wiring system (e.g. by its own weight in vertical runs) a suitable type of cable or conductor with appropriate cross-sectional areas and method of mounting shall be selected in such a manner that the conductors or cables do not suffer damage by their own weight.

52-2.8.6 Wiring systems intended for the drawing in or out of conductors or cables shall have adequate means of access to allow this operation.

52-2.8.7 Wiring systems buried in floors shall be sufficiently protected to prevent damage caused by the intended use of the floor.

52-2.8.8 Wiring systems which are rigidly fixed and buried in the walls shall be run horizontally or vertically or parallel to the room edges.

Wiring systems concealed in the structure but not fixed may follow the shortest practical route.

52-2.8.9 Flexible wiring systems shall be installed so that excessive tensile stress to the conductors and connections is avoided.

52-2.9 Presence of flora and/or mould growth (AK)

52-2.9.1 Where the conditions experienced or expected constitute a hazard (AK2), the wiring system shall be selected accordingly or special protective measures shall be adopted.

NOTE An installation method, which facilitates the removal of such growths may be necessary (see 52-9).

52-2.10 Presence of fauna (AL)

52-2.10.1 Where conditions experienced or expected constitute a hazard (AL2) the wiring system shall be selected accordingly or special protective measures shall be adopted, for example, by:

- the mechanical characteristics of the wiring system; or
- the location selected; or
- the provision of additional local or general mechanical protection; or
- by any combination of the above.

52-2.11 Solar radiation (AN)

52-2.11.1 Where significant solar radiation (AN2) is experienced or expected, a wiring system suitable for the conditions shall be selected and erected or adequate shielding shall be provided.

NOTE See also 52-2.2.1 dealing with temperature rise.

52-2.12 Seismic effects (AP)

52-2.12.1 The wiring system shall be selected and erected with due regard to the seismic hazards of the location of the installation.

52-2.12.2 Where the seismic hazards experienced are low severity (AP2) or higher, particular attention shall be paid to the following:

- the fixing of wiring systems to the building structure;
- the connections between the fixed wiring and all items of essential equipment, e.g. safety services, shall be selected for their flexible quality.

52-2.13 **Wind (AR)**

52-2.13.1 See 52-2.7, Vibration (AH), and 52-2.8, other mechanical stresses (AJ).

52-2.14 **Nature of processed or stored materials (BE)**

52-2.14.1 See 52-7, Selection and erection of wiring systems to minimize the spread of fire.

52-2.15 **Building design (CB)**

52-2.15.1 Where risks due to structural movement exist (CB3), the cable support and protection system employed shall be capable of permitting relative movement so that conductors and cables are not subjected to excessive mechanical stress.

52-2.15.2 For flexible or unstable structures (CB4), flexible wiring systems shall be used.

52-3 **Current-carrying capacities**

52-3.1 The current to be carried by any conductor for sustained periods during normal operation shall be such that the appropriate temperature limit specified in Table 52-4 is not exceeded. The value of current shall be selected in accordance with 52-3.2, or determined in accordance with 52-3.3.

Table 52-4 Maximum operating temperatures for types of insulation

Type of insulation	Temperature limit[a] °C
Polyvinyl-chloride (PVC)	70 at the conductor
Cross-linked polyethylene (XLPE) and ethylene propylene rubber (EPR)	90 at the conductor [b]
Mineral (PVC covered or bare exposed to touch)	70 at the sheath
Mineral (bare not exposed to touch and not in contact with combustible material)	105 at the sheath [b, c]

[a] The maximum permissible conductor temperatures given in Table 52-4 on which the tabulated current-carrying capacities given in annex A are based, have been taken from SASO 1592, SASO 1694, SASO 1700 and SASO IEC 60702 and are shown on these tables.

[b] Where a conductor operates at a temperature exceeding 70°C it shall be ascertained that the equipment connected to the conductor is suitable for the resulting temperature at the connection.

[c] For mineral insulated cables, higher operating temperatures may be permissible dependent upon the temperature rating of the cable, its terminations, the environmental conditions and other external influences.

52-3.2 The requirement of 52-3.1 is considered to be satisfied if the current for insulated conductors and cables without armour does not exceed the appropriate values selected from the tables in Annex A.52 with reference to Table 52-3, subject to any necessary correction factors given in Annex A.52.

52-3.3 The appropriate value of current-carrying capacities may also be determined as described in SASO IEC 60287 or by test, or by calculation using a

recognized method, provided that the method is stated. Where appropriate, account shall be taken of the characteristics of the load and, for buried cables, the effective thermal resistance of the soil.

52-3.4 The ambient temperature is the temperature of the surrounding medium when the cable(s) or insulated conductor(s) under consideration are not loaded.

52-3.5 Groups containing more than one circuit

The group reduction factors are applicable to groups of insulated conductors or cables having the same maximum operating temperature.

For groups containing cables or insulated conductors having different maximum operating temperatures, the current-carrying capacity of all the cables or insulated conductors in the group shall be based on the lowest maximum operating temperature of any cable in the group together with the appropriate group reduction factor.

If, due to known operating conditions, a cable or insulated conductor is expected to carry a current not greater than 30 % of its grouped rating, it may be ignored for the purpose of obtaining the reduction factor for the rest of the group.

52-3.6 Number of loaded conductors

52-3.6.1 The number of conductors to be considered in a circuit are those carrying load current. Where it can be assumed that conductors in polyphase circuits carry balanced currents, the associated neutral conductor need not be taken into consideration. Under these conditions a four-core cable is given the same capacity as a three-core cable having the same conductor cross-sectional area for each phase conductor. Four and five core cables may have higher current-carrying capacities when only three conductors are loaded.

52-3.6.2 Where the neutral conductor in a multi-core cable carries current as a result of an unbalance in the phase currents the temperature rise due to the neutral current is offset by the reduction in the heat generated by one or more of the phase conductors. In this case the conductor size shall be chosen on the basis of the highest phase current.

In all cases the neutral conductor shall have a cross-sectional area adequate to afford compliance with 52-3.1.

52-3.6.3 Where the neutral conductor carries current without corresponding reduction in load of the phase conductors, the neutral conductor shall be taken into account in ascertaining the rating of the circuit. Such currents may be caused by a significant harmonic current in three-phase circuits. If the harmonic content is greater than 10 % the neutral conductor shall not be smaller than the phase conductors. Thermal affects due to the presence of harmonic currents and the corresponding reduction factors for higher harmonic currents are given in annex D.

52-3.6.4 Conductors, which serve the purpose of protective conductors only (PE conductors), are not to be taken into consideration. PEN conductors shall be taken into consideration in the same way as neutral conductors.

52-3.7 Conductors in parallel

Where two or more conductors are connected in parallel in the same phase or pole of the system, either:

52-3.7.1 measures shall be taken to achieve equal load current sharing between them; This requirement is considered to be fulfilled if the conductors are of the same material, have the same cross-sectional area, are approximately the same length and have no branch circuits along the length, and

52-3.7.2 either the conductors in parallel are multi-core cables or twisted single-core cables or insulated conductors, or

- the conductors in parallel are non-twisted single-core cables or insulated conductors in trefoil or flat formation and have a cross-sectional area less than or equal to 50 mm^2 in copper or 70 mm^2 in aluminium;
- or (if the conductors in parallel are non-twisted single-core cables or insulated conductors in trefoil or in flat formation and have cross-sectional areas greater than 50 mm^2 in copper or 70 mm^2 in aluminium) the special configuration necessary for such formations are adopted. These configurations consist of suitable groupings and spacings of the different phases or poles; or
- special consideration shall be given to the load current sharing to meet the requirements of 52-3.1.

52-3.8 Variation of installation conditions along a route

Where the heat dissipation differs in one part of a route to another, the current-carrying capacity shall be determined so as to be appropriate for the part of the route having the most adverse conditions.

52-4 Cross-sectional areas of conductors

52-4.1 The cross-sectional area of line conductors in a.c. circuits and of live conductors in d.c. circuits shall be not less than the values given in Table 52-5.

NOTE This is for mechanical reasons.

52-4.2 The neutral conductor, if any, shall have the same cross-sectional area as the line conductor:

- in single-phase, two-wire circuits whatever the section;
- in polyphase and single-phase three-wire circuits, when the size of the line conductors is less than or equal to 16 mm^2 in copper, or 25 mm^2 in aluminium.

52-4.3 For polyphase circuits where each phase conductor has a cross-sectional area greater than 16 mm^2 in copper or 25 mm^2 in aluminium, the neutral conductor may have a smaller cross-sectional area than that of the line conductors if the following conditions are simultaneously fulfilled:

- the expected maximum current including harmonics, if any, in the neutral conductor during normal service is not greater than the current-carrying capacity of the reduced cross-sectional area of the neutral conductor;

  NOTE The load carried by the circuit under normal service conditions should be practically equally distributed between the phases.
- the neutral conductor is protected against overcurrents according to the rules of 43-1.2;
- the size of the neutral conductor is at least equal to 16 mm^2 in copper or 25 mm^2 in aluminium.

Table 52-5 Minimum cross-sectional area of conductors

<table>
<tr><th colspan="2" rowspan="2">Types of wiring system</th><th rowspan="2">Use of the circuit</th><th colspan="2">Conductor</th></tr>
<tr><th>Material</th><th>Cross-sectional area
mm²</th></tr>
<tr><td rowspan="4">Fixed Installations</td><td rowspan="2">Cables and Insulated conductors</td><td>Power and lighting circuits</td><td>Copper
Aluminium</td><td>1.5
2.5 (see note 1)</td></tr>
<tr><td>Signalling and control circuits</td><td>Copper</td><td>0.5 (see note 2)</td></tr>
<tr><td rowspan="2">Bare conductors</td><td>Power circuits</td><td>Copper
Aluminium</td><td>10
16</td></tr>
<tr><td>Signalling and control circuits</td><td>Copper</td><td>4</td></tr>
<tr><td colspan="2" rowspan="3">Flexible connections with insulated conductors and cables</td><td>For a specific appliance</td><td rowspan="3">Copper</td><td>As specified in the relevant Saudi Standards publication</td></tr>
<tr><td>For any other application</td><td>0.75 [a]</td></tr>
<tr><td>Extra low-voltage circuits for special applications</td><td>0.75</td></tr>
<tr><td colspan="5">NOTE 1 Connectors used to terminate aluminium conductors shall be tested and approved for this specific use.
NOTE 2 In signalling and control circuits intended for electronic equipment a minimum cross-sectional area of 0.1 mm² is permitted.</td></tr>
<tr><td colspan="5">[a)] In multi-core flexible cables containing seven or more cores, note 2 applies.</td></tr>
</table>

52-5 Voltage drop in consumers' installations

It is recommended that in practice the voltage drop between the origin of consumer's installation and the equipment should not be greater than 4 % of the nominal voltage of the installation.

Other considerations include start-up time for motors and equipment with high inrush current.

Temporary conditions such as voltage transients and voltage variation due to abnormal operation may be disregarded.

52-6 Electrical connections

52-6.1 Connections between conductors and between conductors and other equipment shall provide durable electrical continuity and adequate mechanical strength and protection.

NOTE See SASO IEC 61200-52.

52-6.2 The selection of the means of connection shall take account, as appropriate, of:

- the material of the conductor and its insulation;
- the number and shape of the wires forming the conductor;
- the cross-sectional area of the conductor; and
- the number of conductors to be connected together.

NOTE The use of soldered connections should be avoided in power wiring. If used, the connections should be designed to take account of creep and mechanical stresses (see 52-2.6, 52-2.7 and 52-2.8).

52-6.3 All connections shall be accessible for inspection, testing and maintenance, except for the following:

- joints in buried cables;
- compound-filled or encapsulated joints;
- connections between a cold tail and the heating element as in ceiling heating, floor heating and trace heating systems.

52-6.4 Where necessary, precautions shall be taken so that the temperature attained by connections in normal service shall not impair the effectiveness of the insulation of conductors connected to them or supporting them.

52-7 Selection and erection of wiring systems to minimize the spread of fire

52-7.1 Precautions within a fire-segregated compartment

52-7.1.1 The risk of spread of fire shall be minimized by the selection of appropriate materials and erection in accordance with 52-2.

52-7.1.2 Wiring systems shall be installed so that the general building structural performance and fire safety are not reduced.

52-7.1.3 Cables complying with, at least, the requirements of SASO 752 and products having the necessary fire resistance specified in SASO 254, SASO 255 and in other SASO standards for wiring systems may be installed without special precautions.

NOTE In installations where particular risk is identified, cables complying with the more onerous tests for bunched cables described in SASO IEC 60332-3-24 may be necessary.

52-7.1.4 Cables not complying, as a minimum, with the flame propagation requirements of SASO 752 shall, if used, be limited to short lengths for connection of appliances to permanent wiring systems and shall, in any event, not pass from one fire-segregated compartment to another.

52-7.1.5 Parts of wiring systems other than cables which do not comply, as a minimum, with the flame propagation requirements of SASO 254, SASO 255 and other Saudi Standards for wiring systems but which comply in all other respects with the requirements of SASO 254, SASO 255 and other Saudi Standards for wiring systems shall, if used, be completely enclosed in suitable non-combustible building materials.

52-7.2 Sealing of wiring system penetrations

52-7.2.1 Where a wiring system passes through elements of building construction such as floors, walls, roofs, ceilings, partitions or cavity barriers, the openings remaining after passage of the wiring system shall be sealed according to the degree of fire resistance (if any) prescribed for the respective element of building construction before penetration (see ISO 834).

NOTE 1 During erection of a wiring system temporary sealing arrangements may be required.

NOTE 2 During alteration work, sealing should be reinstated as quickly as possible.

52-7.2.2 Wiring systems such as conduits, cable ducting, cable trunking, busbars or busbar trunking systems which penetrate elements of building construction having specified fire resistance shall be internally sealed to the degree of fire resistance of the respective element before penetration as well as being externally sealed as required by 52-7.2.1.

52-7.2.3 52-7.2.1 and 52-7.2.2 are satisfied if the sealing of the wiring system concerned has been type tested.

52-7.2.4 Conduit and trunking systems of material complying with the flame propagation test of SASO 254, SASO 255 and having a maximum internal cross-section area of 710 mm^2 need not be internally sealed provided that

- the system satisfies the test of SASO 980 for IP33; and
- any termination of the system in one of the compartments, separated by the building construction being penetrated, satisfies the test of SASO 980 for IP33.

52-7.2.5 No wiring system shall penetrate an element of building construction, which is intended to be load bearing unless the integrity of the load bearing element can be assured after such penetration (see ISO 834).

52-7.2.6 All sealing arrangements used in accordance with 52-7.2.1 and 52-7.2.3 shall comply with the following requirements and those of 52-7.2.7.

NOTE 1 These requirements may be transferred to an SASO product standard, if such a standard is prepared.

- They should be compatible with the materials of the wiring system with which they are in contact.
- They should permit thermal movement of the wiring system without reduction of the sealing quality.
- They should be of adequate mechanical stability to withstand the stresses, which may arise through damage to the support of the wiring system due to fire.

NOTE 2 This statement may be satisfied if:

- either cable clamps or cable supports are installed within 750 mm of the seal, and are able to withstand the mechanical loads expected following the collapse of the supports on the fire side of the seal to the extent that no strain is transferred to the seal; or
- the design of the sealing system itself provides adequate support.

52-7.2.7 Sealing arrangements intended to satisfy 52-7.2.1 or 52-7.2.2 above shall resist external influences to the same degree as the wiring system with which they are used and in addition they shall meet all of the following requirements:

- they shall be resistant to the products of combustion to the same extent as the elements of building construction which have been penetrated;
- they shall provide the same degree of protection from water penetration as that required for the building construction element in which they have been installed;
- the seal and the wiring system shall be protected from dripping water which may travel along the wiring system or which may otherwise collect around the seal unless the materials used in the seal are all resistant to moisture when finally assembled for use.

52-7.2.8 The sealing arrangements shall be inspected to verify that they conform to the erection instructions associated with the SASO type test for the product concerned. No further test is required following such verification.

52-8 Proximity of wiring systems to other services

52-8.1 Proximity to electrical services

Band I and Band II voltage circuits shall not be contained in the same wiring system unless every cable is insulated for the highest voltage present or one of the following methods is adopted:

- each conductor of a multicore cable is insulated for the highest voltage present in the cable; or
- the cables are insulated for their system voltage and installed in a separate compartment of a cable ducting or cable trunking system; or
- a separate conduit system is employed.

NOTE Special considerations of electrical interference, both electromagnetic and electrostatic, may apply to telecommunications circuits, data transfer circuits and the like.

52-8.2 Proximity to non-electrical services

52-8.2.1 Wiring systems shall not be installed in the vicinity of services which produce heat, smoke or fumes likely to be detrimental to the wiring, unless it is

protected from harmful effects by shielding arranged so as not to affect the dissipation of heat from the wiring.

52-8.2.2 Where a wiring system is routed below services liable to cause condensation (such as water, steam or gas services), precautions shall be taken to protect the wiring system from deleterious effects.

52-8.2.3 Where electrical services are to be installed in proximity to non-electrical services they shall be so arranged that any foreseeable operation carried out on the other services will not cause damage to the electrical services or the converse.

NOTE This may be achieved by:

- suitable spacing between the services; or
- the use of mechanical or thermal shielding.

52-8.2.4 Where an electrical service is located in close proximity to non-electrical services, both the following conditions shall be met:

- wiring systems shall be suitably protected against the hazards likely to arise from the presence of the other services in normal use; and
- protection against indirect contact shall be afforded in accordance with the requirements of 41-3, non-electrical metallic services being considered as extraneous conductive parts.

52-9 Selection and erection of wiring systems in relation to maintainability including cleaning

52-9.1 The knowledge and experience of the person or persons likely to carry out the maintenance shall be taken into account in the selection and erection of the wiring system.

52-9.2 Where it is necessary to remove any protective measure in order to carry out maintenance, provision shall be made so that the protective measure can be reinstated without reduction of the degree of protection originally intended.

52-9.3 Provision shall be made for safe and adequate access to all parts of the wiring system, which may require maintenance.

NOTE In some situations, it may be necessary to provide permanent means of access by ladders, walkways, etc.

Annex A. 52
(normative)

Current-Carrying Capacities

A.52.1 Introduction

The requirements of this annex are intended to provide for a satisfactory life of conductor and insulation subjected to the thermal effects of carrying current for prolonged periods of time in normal service. Other considerations affect the choice of cross-sectional area of conductors, such as the requirements for protection against electric shock (Chapter 41), protection against thermal effects (Chapter 42), overcurrent protection (Chapter 43), voltage drop (see 52-5), and limiting temperatures for terminals of equipment to which the conductors are connected (see 52-6).

For the time being, this annex relates only to non-armoured cables and insulated conductors having a nominal voltage not exceeding 1 kV a.c. or 1.5 kV d.c. This annex does not apply to armoured single-core cables.

NOTE If armoured single-core cables are used, an appreciable reduction of the current-carrying capacities given in this annex may be required. The cable supplier should be consulted. This is also applicable to non-armoured single-core cables in single way metallic ducts (see 52-1.5).

The values in Tables A.52-2 to A.52-13 apply to cables without armour and have been derived in accordance with the methods given in SASO IEC 60287 using such dimensions as specified in SASO IEC 60502 and conductor resistances given in SASO 751. Known practical variations in cable construction (e.g. form of conductor) and manufacturing tolerances result in a spread of possible dimensions and hence current-carrying capacities for each conductor size. Tabulated current-carrying capacities have been selected so as to take account of this spread of values with safety and to lie on a smooth curve when plotted against conductor cross-sectional area.

For multi-core cables having conductors with a cross-sectional area of 25 mm^2 or larger, either circular or shaped conductors are permissible. Tabulated values have been derived from dimensions appropriate to shaped conductors.

A.52.2 Ambient temperature

A.52.2.1 The current-carrying capacities tabulated in this annex assume the following reference ambient temperatures:

- for insulated conductors and cables in air, irrespective of the method of installation: 30°C;
- for buried cables, either directly in the soil or in ducts in the earth: 20°C.

A.52.2.2 Where the ambient temperature in the intended location of the insulated conductors or cables differs from the reference ambient temperature, the appropriate correction factor given in Tables A.52-14 and A.52-15 shall be applied to the values of current-carrying capacity set out in Tables A.52-2 to A.52-13. For buried cables, correction is not needed if the soil temperature exceeds 25°C for only a few weeks a year.

NOTE For cables and insulated conductors in air, where the ambient temperature occasionally exceeds the reference ambient temperature, the possible use of the tabulated current-carrying capacities without correction is under consideration.

A.52.2.3 The correction factors in Tables A.52-14 and A.52-15 do not take account of the increase, if any, due to solar or other infra-red radiation. Where the cables or insulated conductors are subject to such radiation, the current-carrying capacity shall be derived by the methods specified in SASO IEC 60287.

A.52.3 Soil thermal resistivity

The current-carrying capacities tabulated in this annex for cables in the earth relate to a soil thermal resistivity of 2.5 K · m/W. This value is considered necessary as a precaution for worldwide use when the soil type and geographical location are not specified (see SASO IEC 60287-3-1).

In locations where the effective soil thermal resistivity is higher than 2.5 K · m/W, an appropriate reduction in current-carrying capacity shall be made or the soil immediately around the cables shall be replaced by a more suitable material. Such cases can usually be recognized by very dry earth conditions. Correction factors for soil thermal resistivities other than 2.5 K · m/W are given in Table A.52-15.

NOTE The current-carrying capacities tabulated in this annex for cables in the earth are intended to relate only to runs in and around buildings. For other installations, where investigations establish more accurate values of soil thermal resistivity appropriate for the load to be carried, the values of current-carrying capacity may be derived by the methods of calculation given in SASO IEC 60287 or obtained from the cable manufacturer.

A.52.4 Groups of insulated conductors or cables

A.52.4.1 Installation types A to D in Table A.52-1

The current-carrying capacities given in Tables A.52-2 to A.52-7 relate to single circuits consisting of the following numbers of conductors:

- two insulated conductors or two single-core cables, or one twin-core cable;
- three insulated conductors or three single-core cables, or one three-core cable.

Where more insulated conductors or cables are installed in the same group, the group reduction factors specified in Tables A.52-17 to A.52-19 shall be applied.

NOTE The group reduction factors have been calculated on the basis of prolonged steady-state operation at a 100 % load factor for all live conductors. Where the loading is less than 100 % as a result of the conditions of operation of the installation, the group reduction factors may be higher.

A.52.4.2 Installation types E and F in table A.52-1

The current-carrying capacities of Tables A.52-8 to A.52-13 relate to the reference methods of installation.

For installations on trays, cleats and the like, current-carrying capacities for both single circuits and groups shall be obtained by multiplying the capacities given for the relevant arrangements of insulated conductors or cables in free air, as indicated in tables A.52-8 to A.52-13, by the installation and group reduction factors given in tables A.52-20 and A.52-21.

The following notes concern A.52.4.1 and A.52.4.2:

NOTE 1 Group reduction factors have been calculated as averages for the range of conductor sizes, cable types and installation conditions considered. Attention is drawn to the notes under each table. In some instances, a more precise calculation may be desirable.

NOTE 2 Group reduction factors have been calculated on the basis that the group consists of similar equally loaded insulated conductors or cables. When a group contains various sizes of cable or insulated conductor caution should be exercised over the current loading of the smaller ones (see A.52.5).

A.52.5 Groups containing different sizes

Tabulated group reduction factors are applicable to groups consisting of similar equally loaded cables. The calculation of reduction factors for groups containing different sizes of equally loaded insulated conductors or cables is dependent on the total number in the group and the mix of sizes. Such factors cannot be tabulated but must be calculated for each group. The method of calculation of such factors is outside the scope of this standard. Some specific examples of where such calculations may be advisable are given below.

NOTE A group containing sizes of conductor spanning a range of more than three adjacent standard sizes may be considered as a group containing different sizes. A group of similar cables is taken to be a group where the current-carrying capacity of all the cables is based on the same maximum permissible conductor temperature and where the range of conductor sizes in the group spans not more than three adjacent standard sizes.

A.52.5.1 Groups in conduits, cable trunking or cable ducting

The group reduction factor, which is on the safe side, for a group containing different sizes of insulated conductors or cables in conduits, cable trunking or cable ducting is:

$$F = \frac{1}{\sqrt{n}}$$

Where:

F is the group reduction factor.

n is the number of cables or insulated conductors in the group.

The group reduction factor obtained by this equation will reduce the danger of overloading the smaller sizes but may lead to under-utilization of the larger sizes. Such under-utilization can be avoided if large and small sizes of cable or insulated conductor are not mixed in the same group.

The use of a method of calculation specifically intended for groups containing different sizes of insulated conductors or cables in conduit will produce a more precise group reduction factor. This subject is under consideration.

A.52.5.2 Groups on trays

When a group contains different sizes of insulated conductor or cable, caution must be exercised over the current loading of smaller sizes. It is preferable to use a method of calculation specifically intended for groups containing different sizes of insulated conductors or cables.

The group reduction factor obtained in accordance with A.52.5.1 will provide a value, which is on the safe side. This subject is under consideration.

A.52.6 Methods of installation

A.52.6.1 Reference methods

The reference methods are those methods of installation for which the current-carrying capacity has been determined by test or calculation.

Reference methods A1, item 1 of Table 52-3, (insulated conductors in conduit in a thermally insulated wall) and **A2**, item 2 of Table 52-3, (multi-core cable in conduit in a thermally insulated wall).

The wall consists of an outer weatherproof skin, thermal insulation and an inner skin of wood or wood-like material having a thermal conductance of at least 10 $W/m^2 \cdot K$. The conduit is fixed so as to be close to, but not necessarily touching the inner skin. Heat from the cables is assumed to escape through the inner skin only. The conduit can be metal or plastic.

Reference methods B1, item 4 of Table 52-3, (insulated conductors in conduit on a wooden wall) and **B2**, item 5 of Table 52-3, (multi-core cable in conduit on a wooden wall).

Conduit mounted on a wooden wall so that the gap between the conduit and the surface is less than 0.3 times the conduit diameter. The conduit can be metal or plastic. Where the conduit is fixed to a masonry wall the current-carrying capacity of the cable, or insulated conductors, may be higher. This subject is under consideration.

Reference method C, item 20 of Table 52-3, (single-core or multi-core cable on a wooden wall).

Cable mounted on a wooden wall so that the gap between the cable and the surface is less than 0.3 times the cable diameter. Where the cable is fixed to or embedded in a masonry wall the current-carrying capacity may be higher. This subject is under consideration.

NOTE The term "masonry" is taken to include brickwork, concrete, plaster and the like (other than thermally insulating materials).

Reference method D, item 70 of Table 52-3, (multi-core cable in ducts in the earth).

Cable drawn into plastic, earthenware or metallic ducts laid in direct contact with soil having a thermal resistivity of 2.5 $K \cdot m/W$ and a depth of 0.7 m (see also A.52.3).

Reference methods E, F and G, items 32 and 33 of Table 52-3, (single-core or multi-core cable in free air).

A cable so supported that the total heat dissipation is not impeded. Heating due to solar radiation and other sources shall be taken into account. Care shall be taken that natural air convection is not impeded. In practice a clearance between a cable and any adjacent surface of at least 0.3 times the cable external diameter for multi-core cables or 1 times the cable diameter for single-core cables is sufficient to permit the use of current-carrying capacities appropriate to free air conditions.

A.52.6.2 Other methods

Cable on a floor or under a ceiling: this is similar to reference method C except that the rating for a cable on a ceiling is slightly reduced (see Table A.52-17) from the value for a wall or a floor because of the reduction in natural convection.

Cable tray: a perforated tray has a regular pattern of holes so as to facilitate the use of cable fixings. The ratings for cables on perforated trays have been derived from test work utilizing trays where the holes occupied 30 % of the area of the base. If the holes occupy less than 30 % of the area of the base the tray is regarded as imperforated. This is similar to reference method C.

Ladder support: this is of a construction, which offers a minimum of impedance to the air flow around the cables, i.e. supporting metal work under the cables occupies less than 10 % of the plan area.

Cleats and hangers: cable supports, which hold the cable at intervals along its length and permit substantially complete free air flow around the cable.

General notes to Tables A.52-1 to A.52-21.

NOTE 1 Current-carrying capacity is tabulated for those types of insulated conductor and cable and methods of installation, which are commonly used for fixed electrical installations. The tabulated capacities relate to continuous steady-state operation (100 % load factor) for d.c. or a.c. of nominal frequency 50 Hz or 60 Hz.

NOTE 2 Table A.52-1 itemizes the reference methods of installation to which the tabulated current-carrying capacities refer. It is not implied that all these items are necessarily recognized in national rules of all countries.

NOTE 3 For convenience where computer-aided installation design methods are employed; the current-carrying capacities in Tables A.52-2 to A.52-13 can be related to conductor sized by simple formulae. These formulae with appropriate coefficients are given in Annex C.52.

Table A.52-1 Schedule of reference methods of installation which form the basis of the tabulated current-carrying capacities

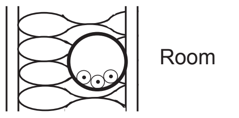
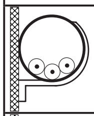
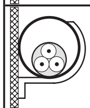
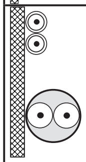
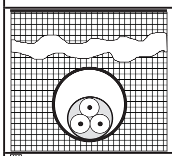
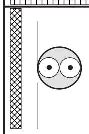
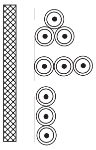
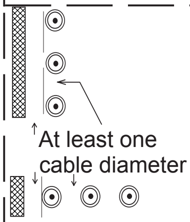
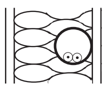
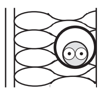
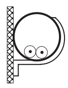
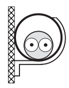
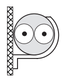
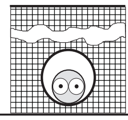
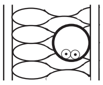
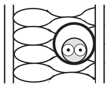
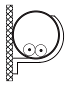
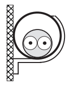
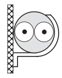
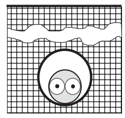
Reference method of installation		Table and column						
		Current-carrying capacities for single circuits					Ambient temperature factor	Group reduction factor
		PVC insulated		XLPE / EPR insulated		Mineral insulated		
		Number of cores						
		2	3	2	3	1, 2 and 3		
1	2	3	4	5	6	7	8	9
 Insulated conductors in conduit in a thermally insulated wall	A1	A.52-2 Col. 2	A.52-4 Col. 2	A.52-3 Col. 2	A.52-5 Col. 2	–	A.52-14	A.52-17
 Multi-core cable in conduit in a thermally insulated wall	A2	A.52-2 Col. 3	A.52-4 Col. 3	A.52-3 Col. 3	A.52-5 Col. 3	–	A.52-14	A.52-17
 Insulated conductors in conduit on a wooden wall	B1	A.52-2 Col. 4	A.52-4 Col. 4	A.52-3 Col. 4	A.52-5 Col. 4	–	A.52-14	A.52-17
 Multi-core cable in conduit on a wooden wall	B2	A.52-2 Col. 5	A.52-4 Col. 5	A.52-3 Col. 5	A.52-5 Col. 5	–	A.52-14	A.52-17
 Single-core or multi-core cable on a wooden wall	C	A.52-2 Col. 6	A.52-4 Col. 6	A.52-3 Col. 6	A.52-5 Col. 6	70°C Sheath 52-C5 105°C Sheath 52-C6	A.52-14	A.52-17
 Multi-core cable in ducts in the earth	D	A.52-2 Col. 7	A.52-4 Col. 7	A.52-3 Col. 7	A.52-5 Col. 7	–	A.52-15	A.52-19
 Clearance to wall not less than 0,3 times cable diameter — Multi-core cable in free air	E	Copper A.52-10 Aluminium A.52-11		Copper A.52-12 Aluminium A.52-13		70°C Sheath A.52-8 105°C Sheath A.52-9	A.52-14	A.52-17
 Clearance to wall not less than one cable diameter — Single-core cables, touching in free air	F	Copper A.52-10 Aluminium A.52-11		Copper A.52-12 Aluminium A.52-13		70°C Sheath A.52-8 105°C Sheath A.52-9	A.52-14	A.52-17
 Single-core cables, spaced in free air	G	Copper A.52-10 Aluminium A.52-11		Copper A.52-12 Aluminium A.52-13		70°C Sheath A.52-8 105°C Sheath A.52-9	A.52-14	–

Table A.52-2 Current-carrying capacities in amperes for methods of installation in table A.52-1– PVC insulation/two loaded conductors/copper or aluminium – Conductor temperature: 70°C/Ambient temperature: 30°C in air, 20°C in earth

Nominal cross-sectional area of conductor mm^2	Installation methods of table A.52-1					
	A1	**A2**	**B1**	**B2**	**C**	**D**
						
1	2	3	4	5	6	7
Copper						
1.5	14.5	14	17.5	16.5	19.5	22
2.5	19.5	18.5	24	23	27	29
4	26	25	32	30	36	38
6	34	32	41	38	46	47
10	46	43	57	52	63	63
16	61	57	76	69	85	81
25	80	75	101	90	112	104
35	99	92	125	111	138	125
50	119	110	151	133	168	148
70	151	139	192	168	213	183
95	182	167	232	201	258	216
120	210	192	269	232	299	246
150	240	219	–	–	344	278
185	273	248	–	–	392	312
240	321	291	–	–	461	361
300	367	334	–	–	530	408
Aluminium						
2.5	15	14.5	18.5	17.5	21	22
4	20	19.5	25	24	28	29
6	26	25	32	30	36	36
10	36	33	44	41	49	48
16	48	44	60	54	66	62
25	63	58	79	71	83	80
35	77	71	97	86	103	96
50	93	86	118	104	125	113
70	118	108	150	131	160	140
95	142	130	181	157	195	166
120	164	150	210	181	226	189
150	189	172	–	–	261	213
185	215	195	–	–	298	240
240	252	229	–	–	352	277
300	289	263	–	–	406	313

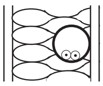
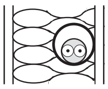
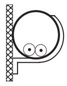
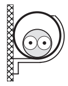
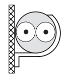
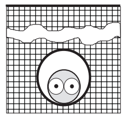
NOTE In columns 3, 5, 6 and 7, circular conductors are assumed for sizes up to and including 16 mm^2. Values for larger sizes relate to shaped conductors and may safely be applied to circular conductors.

Table A.52-3 Current-carrying capacities in amperes for methods of installation in table A.52-1– XLPE or EPR insulation/two loaded conductors/copper or aluminium – Conductor temperature: 90°C/Ambient temperature: 30°C in air, 20°C in earth

Nominal cross-sectional area of conductor mm^2	Installation methods of table A.52-1					
	A1	A2	B1	B2	C	D
						
1	2	3	4	5	6	7
Copper						
1.5	19	18.5	23	22	24	26
2.5	26	25	31	30	33	34
4	35	33	42	40	45	44
6	45	42	54	51	58	56
10	61	57	75	69	80	73
16	81	76	100	91	107	95
25	106	99	133	119	138	121
35	131	121	164	146	171	146
50	158	145	198	175	209	173
70	200	183	253	221	269	213
95	241	220	306	265	328	252
120	278	253	354	305	382	287
150	318	290	–	–	441	324
185	362	329	–	–	506	363
240	424	386	–	–	599	419
300	486	442	–	–	693	474
Aluminium						
2.5	20	19.5	25	23	26	26
4	27	26	33	31	35	34
6	35	33	43	40	45	42
10	48	45	59	54	62	56
16	64	60	79	72	84	73
25	84	78	105	94	101	93
35	103	96	130	115	126	112
50	125	115	157	138	154	132
70	158	145	200	175	198	163
95	191	175	242	210	241	193
120	220	201	281	242	280	220
150	253	230	–	–	324	249
185	288	262	–	–	371	279
240	338	307	–	–	439	322
300	387	352	–	–	508	364

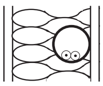
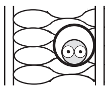
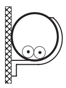
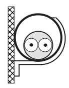
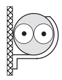
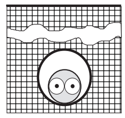
NOTE In columns 3, 5, 6 and 7, circular conductors are assumed for sizes up to and including 16 mm^2. Values for larger sizes relate to shaped conductors and may safely be applied to circular conductors.

Table A.52-4 Current-carrying capacities in amperes for methods of installation in table A.52-1– PVC insulation/three loaded conductors/copper or aluminium – Conductor temperature: 70°C/Ambient temperature: 30°C in air, 20°C in earth

Nominal cross-sectional area of conductor mm^2	Installation methods of table A.52-1					
	A1	A2	B1	B2	C	D
						
1	2	3	4	5	6	7
Copper						
1.5	13.5	13	15.5	15	17.5	18
2.5	18	17.5	21	20	24	24
4	24	23	28	27	32	31
6	31	29	36	34	41	39
10	42	39	50	46	57	52
16	56	52	68	62	76	67
25	73	68	89	80	96	86
35	89	83	110	99	119	103
50	108	99	134	118	144	122
70	136	125	171	149	184	151
95	164	150	207	179	223	179
120	188	172	239	206	259	203
150	216	196	–	–	299	230
185	245	223	–	–	341	258
240	286	261	–	–	403	297
300	328	298	–	–	464	336
Aluminium						
2,5	14	13.5	16.5	15.5	18.5	18.5
4	18.5	17.5	22	21	25	24
6	24	23	28	27	32	30
10	32	31	39	36	44	40
16	43	41	53	48	59	52
25	57	53	70	62	73	66
35	70	65	86	77	90	80
50	84	78	104	92	110	94
70	107	98	133	116	140	117
95	129	118	161	139	170	138
120	149	135	186	160	197	157
150	170	155	–	–	227	178
185	194	176	–	–	259	200
240	227	207	–	–	305	230
300	261	237	–	–	351	260

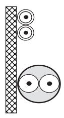
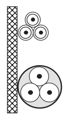
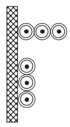
NOTE In columns 3, 5, 6 and 7, circular conductors are assumed for sizes up to and including 16 mm^2. Values for larger sizes relate to shaped conductors and may safely be applied to circular conductors.

Table A.52-5 Current-carrying capacities in amperes for methods of installation in table A.52-1– XLPE or EPR insulation/three loaded conductors/copper or aluminium – Conductor temperature: 90°C/Ambient temperature: 30°C in air, 20°C in earth

Nominal cross-sectional area of conductor mm^2	Installation methods of table A.52-1					
	A1	A2	B1	B2	C	D
						
1	2	3	4	5	6	7
Copper						
1.5	17	16.5	20	19.5	22	22
2.5	23	22	28	26	30	29
4	31	30	37	35	40	37
6	40	38	48	44	52	46
10	54	51	66	60	71	61
16	73	68	88	80	96	79
25	95	89	117	105	119	101
35	117	109	144	128	147	122
50	141	130	175	154	179	144
70	179	164	222	194	229	178
95	216	197	269	233	278	211
120	249	227	312	268	322	240
150	285	259	–	–	371	271
185	324	295	–	–	424	304
240	380	346	–	–	500	351
300	435	396	–	–	576	396
Aluminium						
2.5	19	18	22	21	24	22
4	25	24	29	28	32	29
6	32	31	38	35	41	36
10	44	41	52	48	57	47
16	58	55	71	64	76	61
25	76	71	93	84	90	78
35	94	87	116	103	112	94
50	113	104	140	124	136	112
70	142	131	179	156	174	138
95	171	157	217	188	211	164
120	197	180	251	216	245	186
150	226	206	–	–	283	210
185	256	233	–	–	323	236
240	300	273	–	–	382	272
300	344	313	–	–	440	308

NOTE In columns 3, 5, 6 and 7, circular conductors are assumed for sizes up to and including 16 mm^2. Values for larger sizes relate to shaped conductors and may safely be applied to circular conductors.

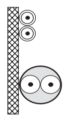
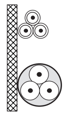
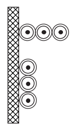
Table A.52-6 Current-carrying capacities in amperes for installation method C of table A.52-1–
Mineral insulation/copper conductors and sheath –
PVC covered or bare exposed to touch (see NOTE 2)
Metallic sheath temperature: 70°C/Reference ambient temperature: 30°C

Nominal cross-sectional area of conductor mm^2	**Number and arrangement of conductors for method C of table A.52-1**		
	Two loaded conductors twin or single-core	**Three loaded conductors**	
		Multi-core or single-core in trefoil formation	**Single-core in flat formation**
			
1	2	3	4
500 V			
1.5	23	19	21
2.5	31	26	29
4	40	35	38
750 V			
1.5	25	21	23
2.5	34	28	31
4	45	37	41
6	57	48	52
10	77	65	70
16	102	86	92
25	133	112	120
35	163	137	147
50	202	169	181
70	247	207	221
95	296	249	264
120	340	286	303
150	388	327	346
185	440	371	392
240	514	434	457

NOTE 1 For single-core cables the sheaths of the cables of the circuit are connected together at both ends.

NOTE 2 For bare cables exposed to touch, values should be multiplied by 0.9.

Table A.52-7 Current-carrying capacities in amperes for installation method C of table A.52-1– Mineral insulation/copper conductors and sheath – Bare cable not exposed to touch and not in contact with combustible material Metallic sheath temperature: 105°C/Reference ambient temperature: 30°C

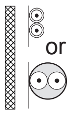
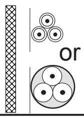
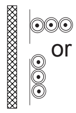
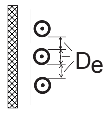
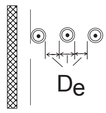
Nominal cross-sectional area of conductor mm²	Number and arrangement of conductors for method C of table A.52-1		
	Two loaded conductors twin or single-core	Three loaded conductors	
		Multi-core or single-core in trefoil formation	Single-core in flat formation
			
1	2	3	4
500 V			
1.5	28	24	27
2.5	38	33	36
4	51	44	47
750 V			
1.5	31	26	30
2.5	42	35	41
4	55	47	53
6	70	59	67
10	96	81	91
16	127	107	119
25	166	140	154
35	203	171	187
50	251	212	230
70	307	260	280
95	369	312	334
120	424	359	383
150	485	410	435
185	550	465	492
240	643	544	572

NOTE 1 For single-core cables, the sheaths of the cables of the circuit are connected together at both ends.

NOTE 2 No correction for grouping need be applied.

NOTE 3 For this table reference method C refers to a masonry wall because the high sheath temperature is not normally acceptable for a wooden wall.

Table A.52-8 Current-carrying capacities in amperes for installation methods E, F and G of table A.52-1– Mineral insulation/Copper conductors and sheath/PVC covered or bare exposed to touch (see NOTE 2)
Metallic sheath temperature: 70°C/Reference ambient temperature: 30°C

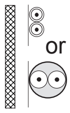
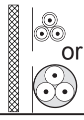
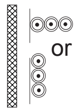
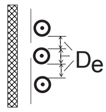
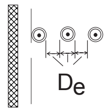
Nominal cross-sectional area of conductor mm²	Number and arrangement of cables for methods E, F and G of table A.52-1				
	Two loaded conductors twin or single-core	Three loaded conductors			
		Multi-core or single-core in trefoil formation	Single-core touching	Single-core flat vertical spaced	Single-core horizontal spaced
	Method E or F	Method E or F	Method F	Method G	Method G
					
1	2	3	4	5	6
500 V					
1.5	25	21	23	26	29
2.5	33	28	31	34	39
4	44	37	41	45	51
750 V					
1.5	26	22	26	28	32
2.5	36	30	34	37	43
4	47	40	45	49	56
6	60	51	57	62	71
10	82	69	77	84	95
16	109	92	102	110	125
25	142	120	132	142	162
35	174	147	161	173	197
50	215	182	198	213	242
70	264	223	241	259	294
95	317	267	289	309	351
120	364	308	331	353	402
150	416	352	377	400	454
185	472	399	426	446	507
240	552	466	496	497	565

NOTE 1 For single-core cables the sheaths of the cables of the circuit are connected together at both ends.

NOTE 2 For bare cables exposed to touch, values should be multiplied by 0.9.

NOTE 3 D_e is the external diameter of the cable.

Table A.52-9 Current-carrying capacities in amperes for installation methods E, F and G of table A.52-1– Mineral insulation/Copper conductors and sheath/ Bare cable not exposed to touch (see NOTE 2)
Metallic sheath temperature: 105°C/Reference ambient temperature: 30°C

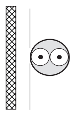
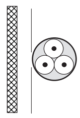
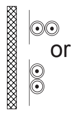
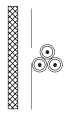
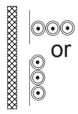
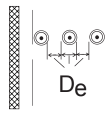
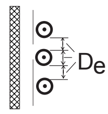
Nominal cross-sectional area of conductor mm^2	Number and arrangement of cables for methods E, F and G of table A.52-1				
	Two loaded conductors, twin or single-core	Three loaded conductors			
		Multi-core or single-core in trefoil formation	Single-core touching	Single-core flat vertical spaced	Single-core horizontal spaced
	Method E or F	Method E or F	Method F	Method G	Method G
					
1	2	3	4	5	6
500 V					
1.5	31	26	29	33	37
2.5	41	35	39	43	49
4	54	46	51	56	64
750 V					
1.5	33	28	32	35	40
2.5	45	38	43	47	54
4	60	50	56	61	70
6	76	64	71	78	89
10	104	87	96	105	120
16	137	115	127	137	157
25	179	150	164	178	204
35	220	184	200	216	248
50	272	228	247	266	304
70	333	279	300	323	370
95	400	335	359	385	441
120	460	385	411	441	505
150	526	441	469	498	565
185	596	500	530	557	629
240	697	584	617	624	704

NOTE 1 For single-core cables the sheaths of the cables of the circuit are connected together at both ends.

NOTE 2 No correction for grouping need be applied.

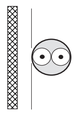
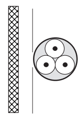
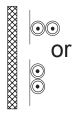
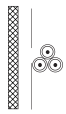
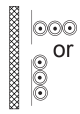
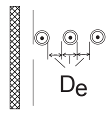
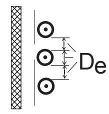
NOTE 3 D_e is the external diameter of the cable.

Table A.52-10 Current-carrying capacities in amperes for installation methods E, F and G of table A.52-1– PVC insulation/Copper conductors Conductor temperature: 70°C/Reference ambient temperature: 30°C

Nominal cross-sectional area of conductor mm²	Installation methods of table A.52-1						
	Multi-core cables		Single-core cables				
	Two loaded conductors	Three loaded conductors	Two loaded conductors touching	Three loaded conductors trefoil	Three loaded conductors, flat		
					Touching	Spaced	
						Horizontal	Vertical
	 Method E	 Method E	 Method F	 Method F	 Method F	 Method G	 Method G
1	2	3	4	5	6	7	8
1.5	22	18.5	–	–	–	–	–
2.5	30	25	–	–	–	–	–
4	40	34	–	–	–	–	–
6	51	43	–	–	–	–	–
10	70	60	–	–	–	–	–
16	94	80	–	–	–	–	–
25	119	101	131	110	114	146	130
35	148	126	162	137	143	181	162
50	180	153	196	167	174	219	197
70	232	196	251	216	225	281	254
95	282	238	304	264	275	341	311
120	328	276	352	308	321	396	362
150	379	319	406	356	372	456	419
185	434	364	463	409	427	521	480
240	514	430	546	485	507	615	569
300	593	497	629	561	587	709	659
400	–	–	754	656	689	852	795
500	–	–	868	749	789	982	920
630	–	–	1 005	855	905	1 138	1 070

NOTE Circular conductors are assumed for sizes up to and including 16 mm². Values for larger sizes relate to shaped conductors and may safely be applied to circular conductors.

Table A.52-11 Current-carrying capacities in amperes for installation methods E, F and G of table A.52-1– PVC insulation/Aluminium conductors Conductor temperature: 70°C/Reference ambient temperature: 30°C

Nominal cross-sectional area of conductor mm²	Installation methods of table A.52-1						
	Multi-core cables		Single-core cables				
					Three loaded conductors, flat		
						Spaced	
	Two loaded conductors	Three loaded conductors	Two loaded conductors touching	Three loaded conductors trefoil	Touching	Horizontal	Vertical
							
	Method E	Method E	Method F	Method F	Method F	Method G	Method G
1	2	3	4	5	6	7	8
2.5	23	19.5	–	–	–	–	–
4	31	26	–	–	–	–	–
6	39	33	–	–	–	–	–
10	54	46	–	–	–	–	–
16	73	61	–	–	–	–	–
25	89	78	98	84	87	112	99
35	111	96	122	105	109	139	124
50	135	117	149	128	133	169	152
70	173	150	192	166	173	217	196
95	210	183	235	203	212	265	241
120	244	212	273	237	247	308	282
150	282	245	316	274	287	356	327
185	322	280	363	315	330	407	376
240	380	330	430	375	392	482	447
300	439	381	497	434	455	557	519
400	–	–	600	526	552	671	629
500	–	–	694	610	640	775	730
630	–	–	808	711	746	900	852

NOTE Circular conductors are assumed for sizes up to and including 16mm². Values for larger sizes relate to shaped conductors and may safely be applied to circular conductors.

Table A.52-12 Current-carrying capacities in amperes for installation methods E, F and G of table A.52-1– XLPE or EPR insulation/Copper conductors – Conductor temperature: 90°C/Reference ambient temperature: 30°C

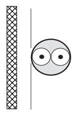
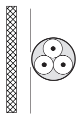
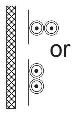
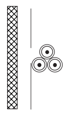
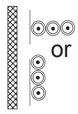
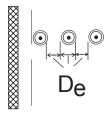
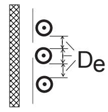
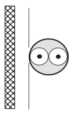
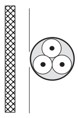
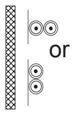
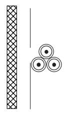
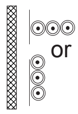
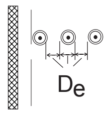
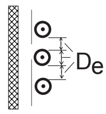
Nominal cross-sectional area of conductor mm^2	Installation methods of table A.52-1						
	Multi-core cables		Single-core cables				
	Two loaded conductors	Three loaded conductors	Two loaded conductors touching	Three loaded conductors trefoil	Three loaded conductors, flat		
					Touching	Spaced	
						Horizontal	Vertical
	 Method E	 Method E	 Method F	 Method F	 Method F	 Method G	 Method G
1	2	3	4	5	6	7	8
1.5	26	23	–	–	–	–	–
2.5	36	32	–	–	–	–	–
4	49	42	–	–	–	–	–
6	63	54	–	–	–	–	–
10	86	75	–	–	–	–	–
16	115	100	–	–	–	–	–
25	149	127	161	135	141	182	161
35	185	158	200	169	176	226	201
50	225	192	242	207	216	275	246
70	289	246	310	268	279	353	318
95	352	298	377	328	342	430	389
120	410	346	437	383	400	500	454
150	473	399	504	444	464	577	527
185	542	456	575	510	533	661	605
240	641	538	679	607	634	781	719
300	741	621	783	703	736	902	833
400	–	–	940	823	868	1085	1008
500	–	–	1083	946	998	1253	1169
630	–	–	1 254	1 088	1 151	1 454	1 362
NOTE Circular conductors are assumed for sizes up to and including 16 mm^2. Values for larger sizes relate to shaped conductors and may safely be applied to circular conductors.							

Table A.52-13 Current-carrying capacities in amperes for installation methods E, F and G of table A.52-1 – XLPE or EPR insulation/Aluminium conductors Conductor temperature: 90°C/Reference ambient temperature: 30°C

Nominal cross-sectional area of conductor mm²	Installation methods of table A.52-1						
	Multi-core cables		Single-core cables				
	Two loaded conductors	Three loaded conductors	Two loaded conductors touching	Three loaded conductors trefoil	Three loaded conductors, flat		
					Touching	Spaced	
						Horizontal	Vertical
	 Method E	 Method E	 Method F	 Method F	 Method F	 Method G	 Method G
1	2	3	4	5	6	7	8
2.5	28	24	–	–	–	–	–
4	38	32	–	–	–	–	–
6	49	42	–	–	–	–	–
10	67	58	–	–	–	–	–
16	91	77	–	–	–	–	–
25	108	97	121	103	107	138	122
35	135	120	150	129	135	172	153
50	164	146	184	159	165	210	188
70	211	187	237	206	215	271	244
95	257	227	289	253	264	332	300
120	300	263	337	296	308	387	351
150	346	304	389	343	358	448	408
185	397	347	447	395	413	515	470
240	470	409	530	471	492	611	561
300	543	471	613	547	571	708	652
400	–	–	740	663	694	856	792
500	–	–	856	770	806	991	921
630	–	–	996	899	942	1154	1077

NOTE Circular conductors are assumed for sizes up to and including 16 mm². Values for larger sizes relate to shaped conductors and may safely be applied to circular conductors.

Table A.52-14 Correction factor for ambient air temperatures other than 30°C to be applied to the current-carrying capacities for cables in the air

Ambient temperature [a] °C	Insulation			
	PVC	XLPE and EPR	Mineral [a]	
			PVC covered or bare and exposed to touch 70°C	Bare not exposed to touch 105°C
10	1.22	1.15	1.26	1.14
15	1.17	1.12	1.20	1.11
20	1.12	1.08	1.14	1.07
25	1.06	1.04	1.07	1.04
35	0.94	0.96	0.93	0.96
40	0.87	0.91	0.85	0.92
45	0.79	0.87	0.87	0.88
50	0.71	0.82	0.67	0.84
55	0.61	0.76	0.57	0.80
60	0.50	0.71	0.45	0.75
65	–	0.65	–	0.70
70	–	0.58	–	0.65
75	–	0.50	–	0.60
80	–	0.41	–	0.54
85	–	–	–	0.47
90	–	–	–	0.40
95	–	–	–	0.32

[a] For higher ambient temperatures, consult manufacturer.

Table A.52-15 Correction factors for ambient earth temperatures other than 20°C to be applied to the current-carrying capacities for cables in ducts in the earth

Earth temperature °C	Insulation	
	PVC	XLPE and EPR
10	1.10	1.07
15	1.05	1.04
25	0.95	0.96
30	0.89	0.93
35	0.84	0.89
40	0.77	0.85
45	0.71	0.80
50	0.63	0.76
55	0.55	0.71
60	0.45	0.65
65	–	0.60
70	–	0.53
75	–	0.46
80	–	0.38

Table A.52-16 Correction factors for cables in buried ducts for soil thermal resistivities other than 2.5 K·m/W to be applied to the current-carrying capacities for reference method D

Thermal resistivity, K·m/W	1	1.5	2	2.5	3
Correction factor	1.18	1.1	1.05	1	0.96

NOTE 1 The correction factors given have been averaged over the range of conductor sizes and types of installation included in Tables A.52-2 to A.52-5. The overall accuracy of correction factors is within ±5 %.

NOTE 2 The correction factors are applicable to cables drawn into buried ducts; for cables laid direct in the earth the correction factors for thermal resistivities less than 2.5 K·m/W will be higher. Where more precise values are required they may be calculated by methods given in SASO IEC 60287.

NOTE 3 The correction factors are applicable to ducts buried at depths of up to 0.8 m.

Table A.52-17 Reduction factors for groups of more than one circuit or of more than one multi-core cable to be used with current-carrying capacities of tables A.52-2 to A.52-13

Item	Arrangement (cables touching)	Number of circuits or multi-core cables												To be used with current-carrying capacities, reference
		1	2	3	4	5	6	7	8	9	12	16	20	
1	Bunched in air, on a surface, embedded or enclosed	1.00	0.80	0.70	0.65	0.60	0.57	0.54	0.52	0.50	0.45	0.41	0.38	A.52-2 to A.52-13 Methods A to F
2	Single layer on wall, floor or unperforated tray	1.00	0.85	0.79	0.75	0.73	0.72	0.72	0.71	0.70	No further reduction factor for more than nine circuits or multicore cables			A.52-2 to A.52-7 Method C
3	Single layer fixed directly under a wooden ceiling	0.95	0.81	0.72	0.68	0.66	0.64	0.63	0.62	0.61				
4	Single layer on a perforated horizontal or vertical tray	1.00	0.88	0.82	0.77	0.75	0.73	0.73	0.72	0.72				A.52-8 to A.52-13 Methods E and F
5	Single layer on ladder support or cleats etc.,	1.00	0.87	0.82	0.80	0.80	0.79	0.79	0.78	0.78				

NOTE 1 These factors are applicable to uniform groups of cables, equally loaded.

NOTE 2 Where horizontal clearances between adjacent cables exceeds twice their overall diameter, no reduction factor need be applied.

NOTE 3 The same factors are applied to:
– groups of two or three single-core cables;
– multi-core cables.

NOTE 4 If a system consists of both two- and three-core cables, the total number of cables is taken as the number of circuits, and the corresponding factor is applied to the tables for two loaded conductors for the two-core cables, and to the tables for three loaded conductors for the three-core cables.

NOTE 5 If a group consists of *n* single-core cables it may either be considered as *n*/2 circuits of two loaded conductors or *n*/3 circuits of three loaded conductors.

NOTE 6 The values given have been averaged over the range of conductor sizes and types of installation included in tables A.52-2 to A.52-13 the overall accuracy of tabulated values is within 5 %.

NOTE 7 For some installations and for other methods not provided for in the above table, it may be appropriate to use factors calculated for specific cases, see for example Tables A.52-20 to A.52-21.

Table A.52-18 Reduction factors for more than one circuit, cables laid directly in the earth – Installation method D in tables A.52-2 to A.52-5– Single-core or multi-core cables

Number of circuits	Cable to cable clearance (*a*)[a]				
	Nil (cables touching)	One cable diameter	0.125 m	0.25 m	0.5 m
2	0.75	0.80	0.85	0.90	0.90
3	0.65	0.70	0.75	0.80	0.85

4	0.60	0.60	0.70	0.75	0.80
5	0.55	0.55	0.65	0.70	0.80
6	0.50	0.55	0.60	0.70	0.80

[a] Multi-core cables



[a] Single-core cables



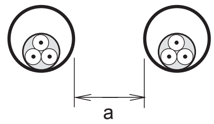
NOTE Values given apply to an installation depth of 0.7 m and a soil thermal resistivity of 2.5 K · m/W. They are average values for the range of cable sizes and types quoted for tables A.52-2 to A.52-5. The process of averaging, together with rounding off, can result in some cases in errors up to ±10 %. (Where more precise values are required they may be calculated by methods given in SASO IEC 60287-2-1).

Table A.52-19 Reduction factors for more than one circuit, cables laid in ducts in the earth – Installation method D in tables A.52-2 to A.52-5

A) Multi-core cables in single-way ducts

Number of cables	Duct to duct clearance (*a*)[a]			
	Nil (ducts touching)	0.25 m	0.5 m	1.0 m
2	0.85	0.90	0.95	0.95
3	0.75	0.85	0.90	0.95
4	0.70	0.80	0.85	0.90
5	0.65	0.80	0.85	0.90
6	0.60	0.80	0.80	0.90

[a] Multi-core cables

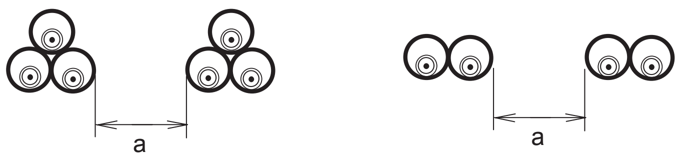


NOTE Values given apply to an installation depth of 0.7 m and a soil thermal resistivity of 2.5 K · m/W. They are average values for the range of cable sizes and types quoted for Tables A.52-2 to A.52-5. The process of averaging, together with rounding off, can result in some cases in errors up to ±10 %. Where more precise values are required they may be calculated by methods given in SASO IEC 60287.

B) Single-core cables in single-way ducts

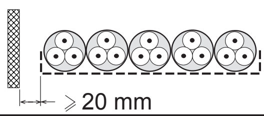
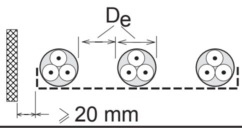
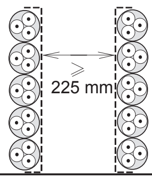
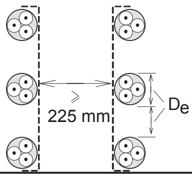
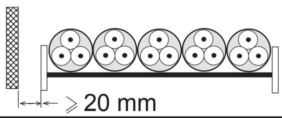
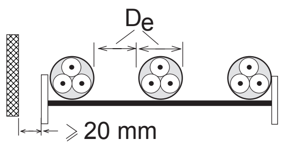
Number of single-core circuits of two or three cables	Duct to duct clearance (*a*)[a]			
	Nil (ducts touching)	0.25 m	0.5 m	1.0 m
2	0.80	0.90	0.90	0.95
3	0.70	0.80	0.85	0.90
4	0.65	0.75	0.80	0.90
5	0.60	0.70	0.80	0.90
6	0.60	0.70	0.80	0.90

[a] Single-core cables



NOTE Values given apply to an installation depth of 0.7 m and a soil thermal resistivity of 2.5 K · m/W. They are average values for the range of cable sizes and types quoted for Tables A.52-2 to A.52-5. The process of averaging, together with rounding off, can result in some cases in errors up to ±10 %. Where more precise values are required they may be calculated by methods given in SASO IEC 60287.

Table A.52-20 Reduction factors for group of more than one multi-core cable to be applied to reference ratings for multi-core cables in free air – Method of installation E in tables A.52-8 to A.52-13

Method of installation in table 52-B2			Number of trays	Number of cables 1	2	3	4	6	9
Perforated trays (note 3)	31	Touching 	1	1.00	0.88	0.82	0.79	0.76	0.73
			2	1.00	0.87	0.80	0.77	0.73	0.68
			3	1.00	0.86	0.79	0.76	0.71	0.66
		Spaced 	1	1.00	1.00	0.98	0.95	0.91	–
			2	1.00	0.99	0.96	0.92	0.87	–
			3	1.00	0.98	0.95	0.91	0.85	–
Vertical perforated trays (note 4)	31	Touching 	1	1.00	0.88	0.82	0.78	0.73	0.72
			2	1.00	0.88	0.81	0.76	0.71	0.70
		Spaced 	1	1.00	0.91	0.89	0.88	0.87	–
			2	1.00	0.91	0.88	0.87	0.85	–
Ladder supports, cleats, etc. (note 3)	32 33 34	Touching 	1	1.00	0.87	0.82	0.80	0.79	0.78
			2	1.00	0.86	0.80	0.78	0.76	0.73
			3	1.00	0.85	0.79	0.76	0.73	0.70
		Spaced 	1	1.00	1.00	1.00	1.00	1.00	–
			2	1.00	0.99	0.98	0.97	0.96	–
			3	1.00	0.98	0.97	0.96	0.93	–

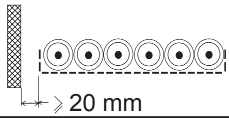
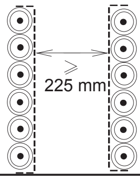
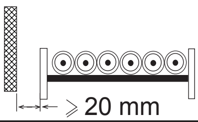
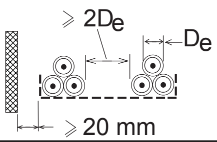
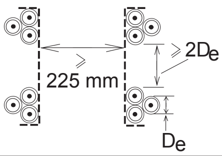
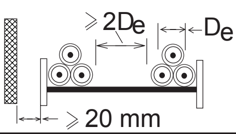
NOTE 1 Values given are averages for the cable types and range of conductor sizes considered in Tables A.52-8 to A.52-13. The spread of values is generally less than 5 %.

NOTE 2 Factors apply to single layer groups of cables as shown above and do not apply when cables are installed in more than one layer touching each other. Values for such installations may be significantly lower and must be determined by an appropriate method.

NOTE 3 Values are given for vertical spacings between trays of 300 mm and at least 20 mm between trays and wall. For closer spacing the factors should be reduced.

NOTE 4 Values are given for horizontal spacing between trays of 225 mm with trays mounted back to back. For closer spacing the factors should be reduced.

Table A.52-21 Reduction factors for groups of more than one circuit of single-core cables (note 2) to be applied to reference rating for one circuit of single-core cables in free air – Method of installation F in tables A.52-8 to A.52-13

Method of installation in table 52-3			Number of trays	Number of three-phase circuits (note 5)			Use as a multiplier to rating for
				1	2	3	
Perforated trays (note 3)	31	Touching 	1 2 3	0.98 0.96 0.95	0.91 0.87 0.85	0.87 0.81 0.78	Three cables in horizontal formation
Vertical perforated trays (note 4)	31	Touching 	1 2	0.96 0.95	0.86 0.84	– –	Three cables in vertical formation
Ladder supports, cleats, etc. (note 3)	32 33 34	Touching 	1 2 3	1.00 0.98 0.97	0.97 0.93 0.90	0.96 0.89 0.86	Three cables in horizontal formation
Perforated trays (note 3)	31		1 2 3	1.00 0.97 0.96	0.98 0.93 0.92	0.96 0.89 0.86	Three cables in trefoil formation
Vertical perforated trays (note 4)	31	Spaced 	1 2	1.00 1.00	0.91 0.90	0.89 0.86	
Ladder supports, cleats, etc. (note 3)	32 33 34		1 2 3	1.00 0.97 0.96	1.00 0.95 0.94	1.00 0.93 0.90	

NOTE 1 Values given are averages for the cable types and range of conductor sizes considered in Table A.52-8 to A.52-13. The spread of values is generally less than 5 %.

NOTE 2 Factors are given for single layers of cables (or trefoil groups) as shown in the table and do not apply when cables are installed in more than one layer touching each other. Values for such installations may be significantly lower and must be determined by an appropriate method.

NOTE 3 Values are given for vertical spacings between trays of 300 mm. For closer spacing the factors should be reduced.

NOTE 4 Values are given for horizontal spacing between trays of 225 mm with trays mounted back to back and at least 20 mm between the tray and any wall. For closer spacing the factors should be reduced.

NOTE 5 For circuits having more than one cable in parallel per phase, each three phase set of conductors should be considered as a circuit for the purpose of this table.

Annex B.52
(informative)

Example of a Method of Simplification of the Tables of 52-3

This annex is intended to illustrate one possible method by which the Tables A.52-2 to A.52-5, A.52-10 to A.52-13 and A.52-17 to A.52-21 can be simplified for adoption in national rules.
The use of other suitable methods is not excluded (see NOTE 1 of 52-3.2).

Table B.52-1 Current-carrying capacity in amperes

Reference methods in table A.52-1	Number of loaded conductors and type of insulation											
A1		Three PVC	Two PVC		Three XLPE	Two XLPE						
A2	Three PVC	Two PVC		Three XLPE	Two XLPE							
B1				Three PVC	Two PVC		Three XLPE		Two XLPE			
B2			Three PVC	Two PVC		Three XLPE	Two XLPE					
C					Three PVC		Two PVC	Three XLPE		Two XLPE		
E						Three PVC		Two PVC	Three XLPE		Two XLPE	
F							Three PVC		Two PVC	Three XLPE		Two XLPE
1	2	3	4	5	6	7	8	9	10	11	12	13
Size (mm^2) Copper												
1.5	13	13.5	14.5	15.5	17	18.5	19.5	22	23	24	26	–
2.5	17.5	18	19.5	21	23	25	27	30	31	33	36	–
4	23	24	26	28	31	34	36	40	42	45	49	–
6	29	31	34	36	40	43	46	51	54	58	63	–
10	39	42	46	50	54	60	63	70	75	80	86	–
16	52	56	61	68	73	80	85	94	100	107	115	–
25	68	73	80	89	95	101	110	119	127	135	149	161
35	–	–	–	110	117	126	137	147	158	169	185	200
50	–	–	–	134	141	153	167	179	192	207	225	242
70	–	–	–	171	179	196	213	229	246	268	289	310
95	–	–	–	207	216	238	258	278	298	328	352	377
120	–	–	–	239	249	276	299	322	346	382	410	437
150	–	–	–	–	285	318	344	371	395	441	473	504
185	–	–	–	–	324	362	392	424	450	506	542	575
240	–	–	–	–	380	424	461	500	538	599	641	679
Aluminium												
2.5	13.5	14	15	16.5	18.5	19.5	21	23	24	26	28	–
4	17.5	18.5	20	22	25	26	28	31	32	35	38	–
6	23	24	26	28	32	33	36	39	42	45	49	–
10	31	32	36	39	44	46	49	54	58	62	67	–
16	41	43	48	53	58	61	66	73	77	84	91	–
25	53	57	63	70	73	78	83	90	97	101	108	121
35	–	–	–	86	90	96	103	112	120	126	135	150
50	–	–	–	104	110	117	125	136	146	154	164	184
70	–	–	–	133	140	150	160	174	187	198	211	237
95	–	–	–	161	170	183	195	211	227	241	257	289
120	–	–	–	186	197	212	226	245	263	280	300	337
150	–	–	–	–	226	245	261	283	304	324	346	389
185	–	–	–	–	256	280	298	323	347	371	397	447
240	–	–	–	–	300	330	352	382	409	439	470	530

NOTE Tables B.52-2 to B.52-3 must be consulted to determine the range of conductor sizes for which the above current-carrying capacities are applicable, for each installation method.

Table B.52-2 Current-carrying capacities (in amperes)

Installation method	Size mm^2	Number of loaded conductors and type of insulation			
		Two PVC	Three PVC	Two XLPE	Three XLPE
D	Copper				
	1.5	22	18	26	22
	2.5	29	24	34	29
	4	38	31	44	37
	6	47	39	56	46
	10	63	52	73	61
	16	81	67	95	79
	25	104	86	121	101
	35	125	103	146	122
	50	148	122	173	144
	70	183	151	213	178
	95	216	179	252	211
	120	246	203	287	240
	150	278	230	324	271
	185	312	258	363	304
	240	361	297	419	351
	300	408	336	474	396
D	Aluminium				
	2.5	22	18.5	26	22
	4	29	24	34	29
	6	36	30	42	36
	10	48	40	56	47
	16	62	52	73	61
	25	80	66	93	78
	35	96	80	112	94
	50	113	94	132	112
	70	140	117	163	138
	95	166	138	193	164
	120	189	157	220	186
	150	213	178	249	210
	185	240	200	279	236
	240	277	230	322	272
	300	313	260	364	308

Table B.52-3 Reduction factors for groups of several circuits or of several multi-core cables (to be used with current-carrying capacities of table B.52-1)

Item	Arrangement	Number of circuits or multi-core cables								
		1	2	3	4	6	9	12	16	20
1	Embedded or enclosed	1.00	0.80	0.70	0.70	0.55	0.50	0.45	0.40	0.40
2	Single layer on walls, floors or on imperforated trays	1.00	0.85	0.80	0.75	0.70	0.70	–	–	–
3	Single layer fixed directly under a ceiling	0.95	0.80	0.70	0.70	0.65	0.60	–	–	–
4	Single layer on perforated horizontal trays or on vertical trays	1.00	0.90	0.80	0.75	0.75	0.70	–	–	–
5	Single layer on cable ladder supports or cleats, etc.	1.00	0.85	0.80	0.80	0.80	0.80	–	–	–

Annex C.52
(informative)

Formulae to Express Current-Carrying Capacities

The values given in Tables A.52-2 to A.52-13 lie on smooth curves relating current-carrying capacity to cross-sectional area of conductor.
These curves can be derived using the following formulae:

$$I = A \times S^{m} - B \times S^{n}$$

Where

I is the current-carrying capacity, in amperes;

S is the nominal cross-sectional area of conductor, in square millimetres (mm^2)[1)];

A and *B* are coefficients and *m* and *n* are exponents according to cable and method of installation.

Values of the coefficients and exponents are given in the accompanying table.
Current-carrying capacities should be rounded off to the nearest 0.5 A for values not exceeding 20 A and to the nearest ampere for values greater than 20 A.
The number of significant figures obtained is not to be taken as an indication of the accuracy of the current-carrying capacity.
For practically all cases only the first term is needed. The second term is needed in only eight cases where large single-core cables are used.
It is not advisable to use these coefficients and exponents for conductor sizes outside the appropriate range used in Tables A.52-2 to A.52-13.

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1) In the case of the 50 mm^2 nominal size, for cables with extruded insulation, the value of 47.5 mm^2 should be used. For all other sizes and for all sizes of mineral insulated cables the nominal value is sufficiently precise.

Table C.52-1 Table of coefficients and exponents

Current-carrying capacity table	Column	Copper conductor		Aluminium conductor	
		A	*m*	*A*	*m*
A.52-2	2	11.2	0.6118	8.61	0.616
	3 ≤ 120 mm^2	10.8	0.6015	8.361	0.6025
	3 > 120 mm^2	10.19	0.6118	7.84	0.616
	4	13.5	0.625	10.51	0.6254
	5	13.1	0.600	10.24	0.5994
	6 ≤ 16 mm^2	15.0	0.625	11.6	0.625
	6 > 16 mm^2	15.0	0.625	10.55	0.640
	7	17.6	0.551	13.5	0.551
A.52-3	2	14.9	0.611	11.6	0.615
	3 ≤ 120 mm^2	14.46	0.598	11.26	0.602
	3 > 120 mm^2	13.56	0.611	10.56	0.615
	4	17.76	0.6250	13.95	0.627
	5	17.25	0.600	13.5	0.603
	6 ≤ 16 mm^2	18.77	0.628	14.8	0.625
	6 > 16 mm^2	17.0	0.650	12.6	0.648
	7	20.8	0.548	15.8	0.550
A.52-4	2	10.4	0.605	7.94	0.612
	3 ≤ 120 mm^2	10.1	0.592	7.712	0.5984
	3 > 120 mm^2	9.462	0.605	7.225	0.612
	4	11.84	0.628	9.265	0.627
	5	11.65	0.6005	9.03	0.601
	6 ≤ 16 mm^2	13.5	0.625	10.5	0.625
	6 > 16 mm^2	12.4	0.635	9.536	0.6324
	7	14.6	0.550	11.3	0.550
A.52-5	2	13.34	0.611	10.9	0.605
	3 ≤ 120 mm^2	12.95	0.598	10.58	0.592
	3 > 120 mm^2	12.14	0.611	9.92	0.605
	4	15.62	0.6252	12.3	0.630
	5	15.17	0.60	11.95	0.605
	6 ≤ 16 mm^2	17.0	0.623	13.5	0.625
	6 > 16 mm^2	15.4	0.635	11.5	0.639
	7	17.3	0.549	13.3	0.551
A.52-6	500 V 2	18.5	0.56	–	–
	3	14.9	0.612	–	–
	4	16.8	0.59	–	–
	750 V 2	19.6	0.596	–	–
	3	16.24	0.5995	–	–
	4	18.0	0.59	–	–
A.52-7	500 V 2	22.0	0.60	–	–
	3	19.0	0.60	–	–
	4	21.2	0.58	–	–
	750 V 2		0.60	–	–
	3	20.3	0.60	–	–
	4	23.88	0.5794	–	–
A.52-8	500 V 2	19.5	0.58	–	–
	3	16.5	0.58	–	–
	4	18.0	0.59	–	–
	5	20.2	0.58	–	–
	6	23.0	0.58	–	–

Table C.52-1 Table of coefficients and exponents *(continued)*

	750 V 2		0.60	–	–
	3	17.4	0.60	–	–
	4	20.15	0.5845	–	–
	5 ≤ 120 mm^2	22.0	0.58	–	–
	5 > 120 mm^2	22.0	0.58	1×10^{-11}	5.25
	6 ≤ 120 mm^2	25.17	0.5785	–	–
	6 > 120 mm^2	25.17	0.5785	1.9×10^{-11}	5.15
A.52-9	500 V 2	24.2	0.58	–	–
	3	20.5	0.58	–	–
	4	23.0	0.57	–	–
	5	26.1	0.549	–	–
	6	29.0	0.57	–	–
	750 V 2	26.04	0.5997	–	–
	3	21.8	0.60	–	–
	4	25.0	0.585	–	–
	5 ≤ 120 mm^2	27.55	0.5792	–	–
	5 > 120 mm^2	27.55	0.5792	1.3×10^{-10}	4.8
	6 ≤ 120 mm^2	31.58	0.5791	–	–
	6 > 120 mm^2	31.58	0.5791	1.8×10^{-7}	3.55
A.52-10	2 ≤ 16 mm^2	16.8	0.62	–	–
	2 > 16 mm^2	14.9	0.646	–	–
	3 ≤ 16 mm^2	14.30	0.62	–	–
	3 > 16 mm^2	12.9	0.64	–	–
	4	17.1	0.632	–	–
	5 ≤ 300 mm^2	13.28	0.6564	–	–
	5 > 300 mm^2	13.28	0.6564	6×10^{-5}	2.14
	6 ≤ 300 mm^2	13.75	0.6581	–	–
	6 > 300 mm^2	13.75	0.6581	1.2×10^{-4}	2.01
	7	18.75	0.637	–	–
	8	15.8	0.654	–	–
A.52-11	2 ≤ 16 mm^2	12.8	0.627	–	–
	2 > 16 mm^2	11.4	0.64	–	–
	3 ≤ 16 mm^2	11.0	0.62	–	–
	3 > 16 mm^2	9.9	0.64	–	–
	4	12.0	0.653	–	–
	5	9.9	0.663	–	–
	6	10.2	0.666	–	–
	7	13.9	0.647	–	–
	8	11.5	0.668	–	–
A.52-12	2 ≤ 16 mm^2	20.5	0.623	–	–
	2 > 16 mm^2	18.6	0.646	–	–
	3 ≤ 16 mm^2	17.8	0.623	–	–
	3 > 16 mm^2	16.4	0.637	–	–
	4	20.8	0.636	–	–
	5 ≤ 300 mm^2	16.0	0.6633	–	–
	5 > 300 mm^2	16.0	0.6633	6×10^{-4}	1.793
	6 ≤ 300 mm^2	16.57	0.665	–	–
	6 > 300 mm^2	16.57	0.665	3×10^{-4}	1.876
	7	22.9	0.644	–	–
	8	19.1	0.662	–	–
A.52-13	2 ≤ 16 mm^2	16.0	0.625	–	–
	2 > 16 mm^2	13.4	0.649	–	–
	3 ≤ 16 mm^2	13.7	0.623	–	–
	3 > 16 mm^2	12.6	0.635	–	–
	4	14.7	0.654	–	–
	5	11.9	0.671	–	–
	6	12.3	0.673	–	–
	7	16.5	0.659	–	–
	8	13.8	0.676	–	–

Annex D.52
(informative)

Effect of Harmonic Currents on Balanced Three-Phase Systems

D.52.1 Reduction factors for harmonic currents in four-core and five-core cables with four cores carrying current

52-3.6.3 states that where the neutral conductor carries current without a corresponding reduction in load of the phase conductors, the current flowing in the neutral conductor shall be taken into account in ascertaining the current-carrying capacity of the circuit.

This Annex is intended to cover the situation where there is current flowing in the neutral of a balanced three-phase system. Such neutral currents are due to the phase currents having a harmonic content, which does not cancel in the neutral. The most significant harmonic, which does not cancel in the neutral, is usually the third harmonic. The magnitude of the neutral current due to the third harmonic may exceed the magnitude of the power frequency phase current. In such a case, the neutral current will have a significant effect on the current-carrying capacity of the cables in the circuit.

The reduction factors given in this annex apply to balanced three-phase circuits; it is recognized that the situation is more onerous if only two of the three phases are loaded. In this situation, the neutral conductor will carry the harmonic currents in addition to the unbalanced current. Such a situation can lead to overloading of the neutral conductor.

Equipment likely to cause significant harmonic currents are, for example, fluorescent lighting banks and d.c. power supplies such as those found in computers. Further information on harmonic disturbances can be found in SASO IEC 61000.

The reduction factors given in table D.52-1 only apply to cables where the neutral conductor is within a four-core or five-core cable and is of the same material and cross-sectional area as the phase conductors. These reduction factors have been calculated based on third harmonic currents. If significant, i.e. more than 10 %, higher harmonics, e.g. 9th, 12th, etc. are expected then lower reduction factors are applicable. Where there is an unbalance between phases of more than 50 % then lower reduction factors may be applicable.

The tabulated reduction factors, when applied to the current-carrying capacity of a cable with three loaded conductors, will give the current-carrying capacity of a cable with four loaded conductors where the current in the fourth conductor is due to harmonics. The reduction factors also take the heating effect of the harmonic current in the phase conductors into account.

Where the neutral current is expected to be higher than the phase current then the cable size should be selected on the basis of the neutral current.

Where the cable size selection is based on a neutral current, which is not significantly higher than the phase current it is necessary to reduce the tabulated current-carrying capacity for three loaded conductors.

If the neutral current is more than 135 % of the phase current and the cable size is selected on the basis of the neutral current then the three phase

conductors will not be fully loaded. The reduction in heat generated by the phase conductors offsets the heat generated by the neutral conductor to the extent that it is not necessary to apply any reduction factor to the current-carrying capacity for three loaded conductors.

Table D.52-1 Reduction factors for harmonic currents in four-core and five-core cables

Third harmonic content of phase current %	Reduction factor	
	Size selection is based on phase current	Size selection is based on neutral current
0 – 15	1.0	–
15 – 33	0.86	–
33 – 45	–	0.86
> 45	–	1.0

D.52.2 Examples of the application of reduction factors for harmonic currents

Consider a three-phase circuit with a design load of 39 A to be installed using four-core PVC insulated cable clipped to a wall, installation method C.

From Table A.52-4 a 6 mm^2 cable with copper conductors has a current-carrying capacity of 41A and hence is suitable if harmonics are not present in the circuit.

If 20 % third harmonic is present, then a reduction factor of 0.86 is applied and the design load becomes:

$$\frac{39}{0.86} = 45\text{A}$$

For this load a 10 mm^2 cable is necessary.

If 40 % third harmonic is present, the cable size selection is based on the neutral current which is:

$$39 \text{ x } 0.4 \text{ x } 3 = 46.8 \text{ A}$$

and a reduction factor of 0.86 is applied, leading to a design load of:

$$\frac{46.8}{0.86} = 54.4 \text{ A}$$

For this load a 10 mm^2 cable is suitable.

If 50 % third harmonic is present, the cable size is again selected on the basis of the neutral current, which is:

$$39 \text{ x } 0.5 \text{ x } 3 = 58.5 \text{ A}$$

In this case the rating factor is 1 and a 16 mm^2 cable is required.

All the above cable selections are based on the current-carrying capacity of the cable; voltage drop and other aspects of design have not been considered.

CHAPTER 53
ISOLATION, SWITCHING AND CONTROL

53-0.1 Scope

This Chapter deals with general requirements for isolation, switching and control and with the requirements for selection and erection of the devices provided to fulfill such functions.

53-0.3 General and common requirements

This Chapter shall provide compliance with the measures of protection for safety, the requirements for proper functioning for intended use of the installation, and the requirements appropriate to the external influences foreseen. Every item of equipment shall be selected and erected so as to allow compliance with the rules stated in the following statements of this Chapter and the relevant rules in other chapters of these Electrical Requirements.

The requirements of this part are supplementary to the common rules given in Chapter 51.

53-0.3.1 The moving contacts of all poles of multipole devices shall be so coupled mechanically that they make and break substantially together, except that contacts solely intended for the neutral may close before and open after the other contacts.

53-0.3.2 Except as provided in 53-6.2.2.7, in multiphase circuits, single-pole devices shall not be inserted in the neutral conductor.

In single-phase circuits single-pole devices shall not be inserted in the neutral conductor, unless a residual current device complying with the rules of 41-3.1 is provided on the supply side.

53-0.3.3 Devices embodying more than one function shall comply with all the requirements of this part appropriate to each separate function.

53-1 Devices for protection against indirect contact by automatic disconnection of supply

53-1.1 Overcurrent protective devices

53-1.1.1 TN systems

In TN systems overcurrent, protective devices shall be selected and erected according to the conditions specified in 43-4.2 and 43-1 of Chapter 43 and in 53-3.3 for devices for protection against short-circuit, and shall satisfy the requirements of 41-3.1.3.3 of Chapter 41.

53-1.1.3 IT systems

Where exposed-conductive-parts are interconnected, overcurrent protective devices for protection in the event of a second fault shall comply with 53-1.1.1 taking into account the requirements of 41-3.1.5.5.

53-1.2 Residual current protective devices

53-1.2.1 General conditions of installation

Residual current protective devices in d.c. systems shall be specially designed for detection of d.c. residual currents, and to break circuit currents under normal conditions and fault conditions.

53-1.2.1.1 A residual current protective device shall ensure the disconnection of all live conductors in the circuit protected. In TN-S systems, the neutral need

not be disconnected if the supply conditions are such that the neutral conductor can be considered to be reliably at earth potential.

53-1.2.1.2 No protective conductor shall pass through the magnetic circuit of a residual current protective device.

53-1.2.1.3 Residual current protective devices shall be so selected, and the electrical circuits so subdivided, that any earth-leakage current, which may be expected to occur during normal operation of the connected load(s) will be unlikely to cause unnecessary tripping of the device.

NOTE Residual current protective devices may operate at any value of residual current in excess of 50% of the rated operating current.

53-1.2.1.4 The use of a residual current protective device associated with circuits not having a protective conductor, even if the rated operating residual current does not exceed 30 mA, shall not be considered as a measure sufficient for protection against indirect contact.

53-1.2.2 Selection of devices according to their method of application

53-1.2.2.1 Residual current protective devices may or may not have an auxiliary source, taking into account the requirements of 53-1.2.2.2.

NOTE The auxiliary source may be the supply system.

53-1.2.2.2 The use of residual current protective devices with an auxiliary source not operating automatically in the case of failure of the auxiliary source is permitted only if one of the two following conditions is fulfilled:

- protection against indirect contact according to 41-3.1 is ensured even in the case of failure of the auxiliary supply;
- the devices are installed in installations operated, tested and inspected by instructed persons (BA4) or skilled persons (BA5).

53-1.2.2.3 A residual current device shall be located so that its operation will not be impaired by magnetic fields caused by other equipment.

53-1.2.3 TN systems

If for certain equipment or for certain parts of the installation, one or more of the conditions stated in 41-3.1.3 cannot be satisfied, those parts may be protected by a residual current protective device. In this case, exposed-conductive-parts need not be connected to the TN earthing system protective conductor, provided that they are connected to an earth electrode affording a resistance appropriate to the operating current of the residual current protective device. The circuit thus protected is to be treated as a TT system and 41-3.1.4 applies.

If, however, no separate earth electrode exists, connection of the exposed-conductive-parts to the protective conductor needs to be made on the source side of the residual current protective device.

53-1.2.4 TT systems

If an installation is protected by a single residual current protective device this shall be placed at the origin of the installation, unless the part of the installation between the origin and the device complies with the requirement for protection by the use of class II equipment or equivalent insulation (see 41-3.2 of Chapter 41).

NOTE Where there is more than one origin, this requirement applies to each origin.

53-1.2.5 IT systems

Where protection is provided by a residual current protective device, and disconnection following a first fault is not envisaged, the residual non-

operating current of the device shall be at least equal to the current which circulates on the first fault to earth of negligible impedance affecting a phase conductor.

53-1.3 Insulation monitoring devices

NOTE Insulation monitoring devices may operate with an appropriate response time.

An insulation monitoring device provided in accordance with 41-3.1.5.4 is a device continuously monitoring the insulation of an electrical installation. It is intended to indicate a significant reduction in the insulation level of the installation to allow the cause of this reduction to be found before the occurrence of a second fault, and thus avoid disconnection of the supply.

Accordingly, it is set at a value below that specified in 61-2 of Chapter 61 appropriate to the installation concerned.

Insulation monitoring devices shall be so designed or installed that it shall be possible to modify the setting only by the use of a key or a tool.

53-3 Devices for protection against overcurrent

53-3.1 General requirements

For every overcurrent protection device there shall be provided on or adjacent to it an indication of its intended nominal current as appropriate to the circuit it protects.

53-3.1.1 Fuse bases using screw-in fuses shall be connected so that the center contact is on the supply side of the fuse base.

53-3.1.2 Fuse bases for plug-in fuse carriers shall be arranged so as to exclude the possibility of the fuse carrier making contact between conductive parts belonging to two adjacent fuse bases.

53-3.1.3 Fuses having fuse-links likely to be removed or placed by persons other than instructed (BA4) or skilled persons (BA5) shall be of a type which complies with the safety requirements of SASO IEC 60269-3.

Fuses or combination units having fuse-links likely to be removed and replaced only by instructed persons (BA4) or skilled persons (BA5) shall be installed in such a manner that it is ensured that the fuse-links can be removed or placed without unintentional contact with live parts.

53-3.1.4 Where circuit-breakers may be operated by persons other than instructed persons (BA4) or skilled persons (BA5), they shall be so designed or installed that it shall not be possible to modify the setting of the calibration of their overcurrent releases without a deliberate act involving the use of a key or tool, and resulting in a visible indication of their setting or calibration.

53-3.1.5 Where necessary to prevent danger, the characteristics and setting of a device for overcurrent protection shall be such that any intended discrimination in its operation is achieved.

53-3.2 Selection of devices for protection of wiring systems against overloads

The nominal current (or current setting) of the protective device shall be chosen in accordance with 43-3.1 of Chapter 43.

NOTE In certain cases, to avoid unintentional operation, the peak current values of the loads have to be taken into consideration.

In the case of a cyclic load, the values of I_n and I_2 shall be chosen on the basis of values of I_B and I_Z for the thermally equivalent constant load.

Where

I_B is the current for which the circuit is designed;

I_Z is the continuous current-carrying capacity of the cable;

I_n is the nominal current of the protective device;

I_2 is the current ensuring effective operation of the protective device.

53-3.3 Selection of devices for protection of wiring systems against short-circuits

The application of the rules of Chapter 43 for short-circuit duration up to 5 s shall take into account minimum and maximum short-circuit conditions.

Where the standard covering a protective device specifies both a rated service short-circuit breaking capacity, and a rated ultimate short-circuit breaking capacity, it is permissible to select the protective device on the basis of the ultimate short-circuit breaking capacity for the maximum short-circuit conditions. Operational circumstances may, however, make it desirable to select the protective device on the service short-circuit breaking capacity, e.g. where a protective device is placed at the origin of the installation.

53-4 Devices for protection against overvoltages

53-4.1 General

This section contains provisions for the application of voltage limitation to obtain an insulation coordination in the cases described in Chapter 44, SASO IEC 60664-1, SASO IEC 61312-2 and SASO IEC 61643-12.

This section gives the requirements for the selection and erection of

- surge protective devices (SPDs) for electrical installations of buildings to obtain a limitation of transient overvoltages of atmospheric origin transmitted via the supply distribution system and against switching overvoltages;
- SPDs for the protection against transient overvoltages caused by direct lightning strokes or lightning strokes in the vicinity of buildings, protected by a lightning protection system.

This section does not take into account surge protective components, which may be incorporated in the appliances connected to the installation. The presence of such components may modify the behaviour of the main surge protective device of the installation and may need an additional coordination.

This section applies to a.c. power circuits. For d.c. power circuits, the requirements in this section may be applied as far as is useful. For special applications, other or additional requirements may be necessary in the relevant chapter of PART SEVEN.

53-4.2 Selection and erection of SPDs in building installations

53-4.2.1 Use of SPDs

44-3 of Chapter 44 includes protection against overvoltages of atmospheric origin (caused by indirect, distant lightning strokes) and switching overvoltages. This protection is normally provided by the installation of test class II SPDs and if necessary test class III SPDs.

When required in accordance with Chapter 44 or otherwise specified, SPDs shall be installed near the origin of the installation or in the main distribution assembly, closest to the origin of the installation inside the building.

Chapter 802 covers the protection of buildings against the effects of direct lighting strokes according to different protection levels; meanwhile, this chapter describes the correct selection and application of SPDs needed to protect the low-voltage supply systems against the effects of transient surges or over-voltages.

When required in accordance with SASO IEC 62305 or otherwise specified, SPDs shall be installed at the origin of the installation.

Additional SPDs may be necessary to protect sensitive equipment. Such SPDs shall be coordinated with the SPDs installed upstream (see 53-4.2.3.6).

In the case where SPDs are part of the fixed electrical installation, but not mounted inside a distribution board (e.g. in a socket-outlet), their presence shall be indicated by a label on or as near as is reasonably possible to the origin of the circuit under consideration.

53-4.2.2 Connection of SPDs

Surge protective devices at or near the origin of the installation shall be connected at least between the following points (see Annexes A.53, B.53 and C.53):

a) If there is a direct connection between the neutral conductor and the PE at or near the origin of the installation or if there is no neutral conductor:
Between each line conductor and either the main earthing terminal or the main protective conductor, whichever is the shortest route;

NOTE The impedance connecting the neutral to the PE in IT systems is not considered as a direct connection.

b) If there is no direct connection between the neutral conductor and the PE at or near the origin of the installation, then either:

- between each line conductor and either the main earthing terminal or the main protective conductor, and between the neutral conductor and either the main earthing terminal or the protective conductor, whichever is the shortest route – connection type 1; or
- between each line conductor and the neutral conductor and between the neutral conductor and either the main earthing terminal or the protective conductor, whichever route is shorter – connection type 2.

  NOTE If a line conductor is earthed, it is considered to be equivalent to a neutral conductor for the application of this statement.

SPDs at or near the origin of the installation are, in general, installed as shown in Annexes A.53 to C.53 and according to Table 53-2:

Table 53-2 Connection of surge protective devices dependent on system configuration

SPDs connected between	System configuration at the installation point of SPD							
	TT		TN-C	TN-S		IT with distributed neutral		IT without distributed neutral
	Installation according to			Installation according to		Installation according to		
	Connection type 1	Connection type 2		Connection type 1	Connection type 2	Connection type 1	Connection type 2	
each line conductor and neutral conductor	+	•	NA	+	•	+	•	NA
each line conductor and PE conductor	•	NA	NA	•	NA	•	NA	•
neutral conductor and PE conductor	•	•	NA	•	•	•	•	NA
each line conductor and PEN conductor	NA	NA	•	NA	NA	NA	NA	NA
line conductors	+	+	+	+	+	+	+	+

• : mandatory

NA: not applicable

+: optional, in addition

53-4.2.3 Selection of surge protective devices (SPDs)

The SPDs shall comply with SASO IEC 61643-1 Additional information regarding selection and application is given in SASO IEC 61643-12.

53-4.2.3.1 Selection with regard to protection level (U_p)

If 44-3 of Chapter 44 requires SPDs, the protection level U_p of SPDs shall be selected in accordance with impulse withstand voltage category II of Table 44-2 (Chapter 44).

If Chapter 44 requires SPDs for the protection against overvoltages caused by direct lightning strokes, the protection level of these SPDs shall also be selected in accordance with impulse withstand voltage category II of Table 44-2 of Chapter 44.

For example in 220/380 V installations, the protection level U_p shall not exceed 2.5 kV.

When connection type 2 according to 53-4.2.2 is used, the above requirements also apply to the total protection level between line conductors and PE.

When the required protection level cannot be reached with a single set of SPDs, additional, coordinated SPDs shall be applied to ensure the required protection level.

53-4.2.3.2 Selection with regard to continuous operating voltage (U_C)

The maximum continuous operating voltage U_C of SPDs shall be equal to or higher than the shown values in the following Table 53-3.

Table 53–3 Minimum required U_c of the SPD dependent on supply system configuration

SPDs connected between	System configuration of distribution network				
	TT	TN-C	TN-S	IT with distributed neutral	IT without distributed neutral
line conductor and neutral conductor	1.1 U_o	NA	1.1 U_o	1.1 U_o	NA
each line conductor and PE conductor	1.1 U_o	NA	1.1 U_o	$\sqrt{3}\ U_o$ [a]	Line-to-line voltage [a]
neutral conductor and PE conductor	U_o [a]	NA	U_o [a]	U_o [a]	NA
each line conductor and PEN conductor	NA	1.1 U_o	NA	NA	NA
NA: not applicable NOTE 1 U_o is the line-to-neutral voltage of the low-voltage system. NOTE 2 This table is based on SASO IEC 61643-1.					
[A] These values are related to worst case fault conditions, therefore the tolerance of 10 % is not taken into account.					

53-4.2.3.3 Selection with regard to temporary overvoltages (TOVs)

The SPDs selected according to 53-4.2.3 shall withstand the temporary overvoltages due to faults within low-voltage systems (see 44-2 Chapter 44).

This is confirmed by the selection of SPDs which comply with the relevant test requirements of SASO IEC 61643-1.

To fail safely in case of TOVs due to earth faults within the high-voltage system (see 44-2 of Chapter 44), the SPDs connected to the PE shall pass the test of SASO IEC 61643-1.

In addition, SPDs installed in location 4a according to Figure B.53-2 shall withstand such TOVs as defined in test of SASO IEC 61643-1.

53-4.2.3.4 Selection with regard to discharge current (I_n) and impulse current (I_{imp})

If 44-3 of Chapter 44 requires SPDs, the nominal discharge current I_n shall not be less than 5 kA 8/20 for each mode of protection.

In case of installation according to 53-4.2.2 connection type 2, the nominal discharge current I_n for the surge protective device connected between the neutral conductor and the PE shall not be less than 20 kA 8/20 for three-phase systems and 10 kA 8/20 for single-phase systems.

If Chapter 44 requires SPDs, the lightning impulse current I_{imp} according to SASO IEC 61643-1 shall be calculated according to SASO IEC 62305 Further information is given in SASO IEC 61643-12. If the current value cannot be established, the value of I_{imp} shall not be less than 12.5 kA for each mode of protection.

In case of an installation according to 53-4.2.2 connection type 2, the lightning impulse current I_{imp} for the surge protective device connected between the neutral conductor and the PE shall be calculated similarly to the above mentioned standards. If the current value cannot be established the value of $I_{imp,}$ shall not be less than 50 kA for three-phase systems and 25 kA for single-phase systems.

When a single SPD is used for protection according to both SASO IEC 62305 and 44-3 of Chapter 44, the rating of I_n and of I_{imp} shall be in agreement with the above values.

53-4.2.3.5 Selection with regard to the expected short-circuit current

The short-circuit withstand of the SPDs (in case of SPD failure) together with the specified associated (internal or external) overcurrent protective device shall be equal to or higher than the maximum short-circuit current expected at the point of installation taking into account the maximum overcurrent protective devices specified by the SPD manufacturer.

In addition, when a follow current interrupting rating is declared by the manufacturer, it shall be equal to or higher than the expected short-circuit current at the point of installation.

SPDs connected between the neutral conductor and the PE in TT- or TN-systems, which allow a power frequency follow-up current after operation (e.g. spark gaps) shall have a follow current interrupting rating greater or equal to 100 A.

In IT systems, the follow current interrupting rating for SPDs connected between the neutral conductor and the PE shall be the same as for SPDs connected between phase and neutral.

53-4.2.3.6 Co-ordination of SPDs

According to SASO IEC 61312-3 and SASO IEC 61643-12 considerations shall be taken regarding the necessary co-ordination of SPDs in the installation. The SPD manufacturers shall provide sufficient information in their documentation about the way to achieve coordination between SPDs.

53-4.2.4 Protection against overcurrent and consequences of an SPD failure

Protection against SPD’s short-circuits is provided by the overcurrent protective devices F2 (see figures in the Annexes A.53 to D.53) which are to be selected according to the maximum recommended rating for the overcurrent protective device given in the manufacturer’s SPD instructions.

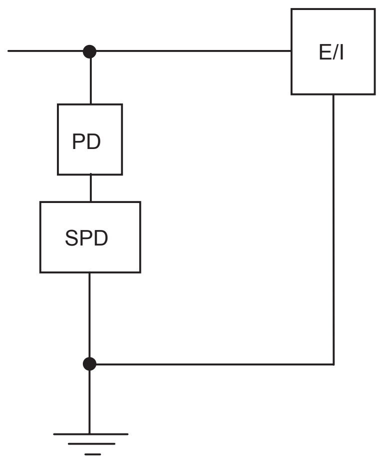
If the overcurrent protective devices F1 (which are part of the installation, see figures in the Annexes A.53 to D.53) have a rating smaller than or equal to the maximum recommended rating for the overcurrent protective devices F2, then F2 can be omitted.

The cross-sectional area of conductors connecting the overcurrent protective devices to the line conductors shall be rated according to the maximum possible short-circuit current (F1, F2 and F3 are shown in Annexes A.53 to D.53).

Depending on the location of protective devices used to disconnect the SPD in case of SPD failure, priority may be given either to the continuity of supply or to the continuity of protection.

In all cases, the discrimination between protective devices shall be ensured.

- If protective devices are installed in the surge protective device circuit, the continuity of the supply is ensured, but neither the installation nor the equipment is protected against possible further overvoltages (see Figure 53-1). These protective devices may be internal disconnections.
- If protective devices are inserted in the installation upstream of the circuit where SPDs are installed, the failure of the surge protective device may cause interruption of supply: the circuit interruption will last until the surge protective device is replaced (see Figure 53-2).



PD: protective device of the SPD

SPD: surge protective device

E/I: equipment or installation to be protected against overvoltages

Figure 53-1 Priority to the continuity of supply

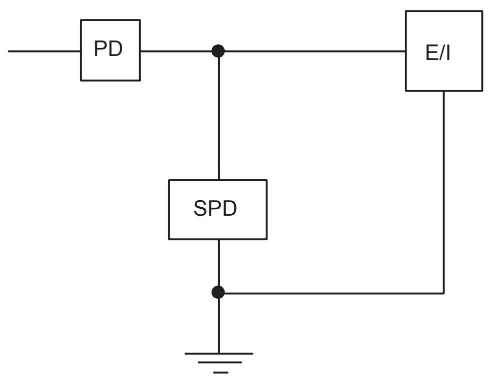


Figure 53–2 Priority to the continuity of protection

In order to increase the reliability and the probability of having at the same time continuity of supply and continuity of protection, it is permitted to use the scheme described in Figure 53-3.

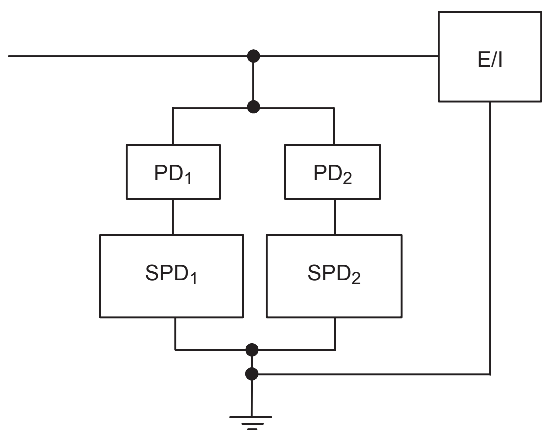


Figure 53–3 Combination of continuity of supply and continuity of protection

In this case, two identical SPDs (SPD_1 and SPD_2) are connected to two identical protective devices (PD_1 and PD_2). The failure mode of one of the SPDs (e.g. SPD_1) will not influence the effectiveness of the second SPD (e.g. SPD_2) and will lead to the operation of its own protective device (e.g. PD_1). Such an arrangement will significantly increase the probability of having continuity of supply and continuity of protection.

53-4.2.5 Protection against indirect contact

Protection against indirect contact, as defined in Chapter 41, shall remain effective in the protected installation even in case of failures of SPDs.

In case of automatic disconnection of supply:

- in TN systems this may, in general, be fulfilled by the overcurrent device on the supply side of the surge protective device;
- in TT systems this may be fulfilled by either:
  - a) the installation of SPDs on the load side of an RCD (see figure B.53-1), or
  - b) the installation of SPDs on the supply side of an RCD. Because of the possibility of the failure of an SPD between N and PE conductors,
- the conditions of Chapter 41, statement 41-3.1.3.7, shall be met, and
- the SPD shall be installed in accordance with 53-4.2.2 connection type 2.
- in IT systems, no additional measure is needed.

53-4.2.6 SPD installation in conjunction with RCDs

If SPDs are installed in accordance with 53-4.2.1 and are on the load side of a residual current device, an RCD with or without time delay, but having an immunity to surge currents of at least 3 kA 8/20 shall be used.

NOTE 1 S-type RCDs in accordance with SASO IEC 61008-1 and SASO IEC 61009-1, satisfy this requirement.

NOTE 2 In the case of surge current higher than 3 kA 8/20, the RCD may trip causing interruption of the power supply.

53-4.2.7 Measurement of the insulation resistance

During the measurement of the insulation resistance of the installation according to Chapter 61, SPDs installed at or near the origin of the installation or in a distribution board and not rated for the test voltage of the insulation measurement may be disconnected.

In the case where SPDs connected to the PE conductor are part of a socket-outlet, they shall withstand the test voltage for measuring the insulation resistance according to Chapter 61.

53-4.2.8 SPD status indication

Indication that the SPD no longer provides overvoltage protection shall be provided:

- either by an SPD status indicator;
- or by a separate SPD protective device such as addressed in 53-4.2.4.

53-4.2.9 Connecting conductors

Connecting conductors are the conductors from the line conductor to the surge protective device and from the surge protective device to the main earthing terminal or to the protective conductor.

Because increasing the length of the connecting conductors of SPDs reduces the effectiveness of overvoltage protection, optimum overvoltage protection is achieved when all connecting conductors of SPDs are as short as possible (preferably not exceeding 0.5 m for the total lead length) and

without any loops, see Figure 53-4. If distance *a* + *b* (see Figure 53-4) cannot be reduced below 0.5 m, the scheme in Figure 53-5 may be adopted.

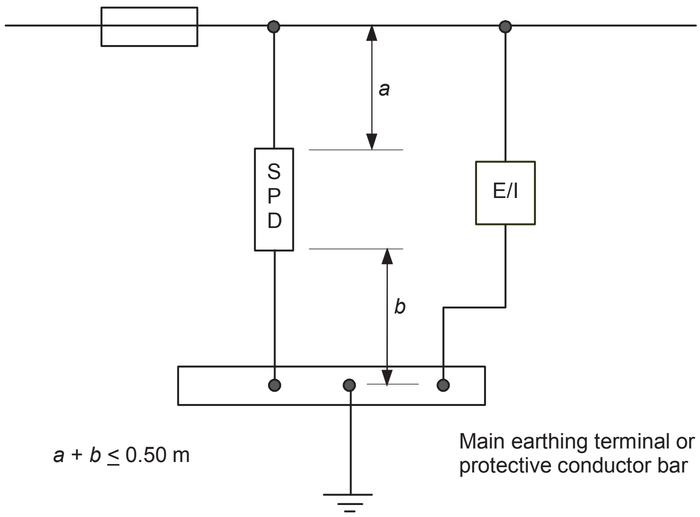


Figure 53–4 Example of installation of SPDs at or near the origin of the installation

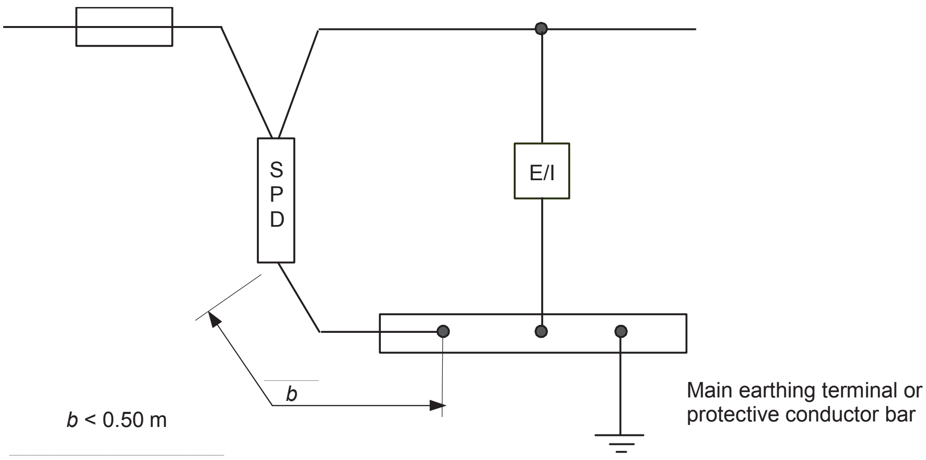


Figure 53–5 Example of installation of SPDs at or near the origin of the installation

53-4.2.10 Cross-section of earthing conductors

The earthing conductors of SPDs at or near the origin of the installation shall have a minimum cross-sectional area of 4 mm^2 copper or equivalent.

When there is a lightning protection system, a minimum cross-sectional area of 16 mm^2 copper or equivalent is necessary for SPDs tested in accordance with test class I of SASO IEC 61643-1.

53-5 Co-ordination of various protective devices

53-5.1 Discrimination between overcurrent protective devices

See 43-7 in Chapter 43.

53-5.2 Association of residual current protective devices with overcurrent protective devices

53-5.2.1 Where a residual current protective device is incorporated or combined with a device for overcurrent protection, the characteristics of the assembly of

protective devices (breaking capacity, operating characteristics in relation to rated current) shall satisfy the rules of 43-3 and 43-4 of Chapter 43, and 53-3.2 and 53-3.3.

53-5.2.2 Where a residual current protective device is neither incorporated in, nor combined with, a device for overcurrent protection:

- overcurrent protection shall be ensured by appropriate protective devices according to the rules of Chapter 43;
- the residual current protective device shall be able to withstand without damage the thermal and mechanical stresses to which it is likely to be subjected in the event of a short-circuit occurring on the load side of the location where it is installed;
- the residual current protective device shall not be damaged under these short-circuit conditions even when, due to unbalanced current or to current flowing to earth, the residual current protective device itself tends to open.

NOTE The stresses mentioned depend on the prospective short-circuit current at the point where the residual current prospective device is installed, and the operating characteristics of the device providing short-circuit protection.

53-5.3 Discrimination between residual current protective devices

Discrimination between residual current protective devices installed in series may be required for service reasons, particularly when safety is involved, to provide continuity of supply to the parts of the installation not involved in the fault, if any.

This discrimination can be achieved by selecting and erecting residual current protective devices which, while ensuring the required protection to the different parts of the installation, disconnect from the supply only that part of the installation that is located on the load side of the residual current protective device installed on the supply side of the fault, and closest to it.

To ensure discrimination between two residual current protective devices in series, these devices shall satisfy both the following conditions:

a) the non-actuating time-current characteristic of the residual current protective device located on the supply side (upstream) shall lie above the total operating time-current characteristic of the residual current protective device located on the load side (downstream), and

b) the rated residual operating current on the device located on the supply side shall be higher than that of the residual current protective device located on the load side.

In the case of residual current protective devices complying with the requirements of SASO IEC 61008-1 and SASO IEC 61009-1, the rated residual operating current of the device located on the supply side shall be at least three times that of the residual current protective device located on the load side.

53-6 Isolation and switching

53-6.0 Introduction

This section deals with non-automatic local and remote isolation and switching measures, which prevent or remove dangers associated with electrical installations or electrically powered equipment and machines.

53-6.1 General

53-6.1.1 According to the intended function(s), every device provided for isolation or switching shall comply with the relevant requirements of this chapter.

53-6.1.2 In TN-C systems, the PEN conductor shall not be isolated or switched. In TN-S systems, the neutral conductor need not be isolated or switched.

NOTE Protective conductors in all systems are required not to be isolated or switched (see also 54-3.3.3 of Chapter 54).

53-6.1.3 The measures described in this chapter are not alternatives to the protective measures described in Chapter 41 to Chapter 44, inclusive.

53-6.2 Isolation

53-6.2.1 General

53-6.2.1.1 Every circuit shall be capable of being isolated from each of the live supply conductors, except as detailed in 53-6.1.2 above.

Provisions may be made for isolation of a group of circuits by a common means, if the service conditions allow this.

53-6.2.1.2 Suitable means shall be provided to prevent any equipment from being unintentionally energized.

NOTE Such precautions may include one or more of the following measures:

- padlocking;
- warning notices;
- location within a lockable space or enclosure.

Short-circuiting and earthing may be used as a supplementary measure.

53-6.2.1.3 Where an item of equipment or enclosure contains live parts connected to more than one supply, a warning notice shall be placed in such a position that any person gaining access to live parts will be warned of the need to isolate those parts from the various supplies unless an interlocking arrangement is provided to ensure that all the circuits concerned are isolated.

53-6.2.1.4 Where necessary, suitable means shall be provided for the discharge of stored electrical energy (see details in Chapter 55).

53-6.2.2 Devices for isolation

53-6.2.2.1 The devices for isolation shall effectively isolate all live supply conductors from the circuit concerned, subject to the provisions of 53-6.1.2.

Equipment used for isolation shall comply with 53-6.2.2.2 to 53-6.2.2.8.

53-6.2.2.2 Devices for isolation shall comply with the following two conditions:

a) withstand in the new, clean and dry condition, when in the open position, across the terminals of each pole, the impulse voltage value given in Table 53-1 in relation to the nominal voltage of the installation.

NOTE Greater distances than those corresponding to the impulse withstand voltages may be necessary from consideration of aspects other than isolation.

Table 53–1 Impulse withstand voltage as a function of the nominal voltage

Nominal voltage of the installation[a]	Impulse withstand voltage for isolating devices kV	
Three-phase systems V	Overvoltage category III	Overvoltage category IV
127/220	3	5
220/380	5	8

[a] According to SASO IEC 60038

NOTE 1 As regards transient atmospheric overvoltages no distinction is made between earthed and unearthed systems.

NOTE 2 The impulse withstand voltages are referred to an altitude of 2 000 m.

b) have a leakage current across open poles not exceeding:

- 0.5 mA per pole in the new, clean and dry condition, and
- 6 mA per pole at the end of the conventional service life of the device as determined in the relevant standard,

when tested, across the terminals of each pole, with a voltage value equal to 110 % of the phase to neutral value corresponding to the nominal voltage of the installation. In the case of d.c. testing, the value of the d.c. voltage shall be the same as the r.m.s. value of the a.c. test voltage.

53-6.2.2.3 The isolating distance between open contacts of the device shall be visible or be clearly and reliably indicated by "off" or "open" marking. Such indication shall only occur when the isolating distance between open contacts on each pole of the device has been attained.

NOTE The marking required by this statement may be achieved by the use of the symbols "O" and "I" to indicate the open and closed positions respectively.

53-6.2.2.4 Semiconductor devices shall not be used as isolating devices.

53-6.2.2.5 Devices for isolation shall be designed and/or installed so as to prevent unintentional closure.

NOTE Such closure might be caused for example by shocks and vibrations.

53-6.2.2.6 Provision shall be made for securing off-load isolating devices against inadvertent and unauthorized opening.

NOTE This may be achieved by locating the device in a lockable space or enclosure or by padlocking. Alternatively, the off-load device may be interlocked with a load-breaking one.

53-6.2.2.7 Means of isolation shall preferably be provided by a multipole switching device which disconnects all poles of the relevant supply but single-pole devices situated adjacent to each other are not excluded.

NOTE Isolation may be achieved, for example, by the following means:

- disconnectors (isolators), switch-disconnectors, multipole or single-pole;
- plugs and socket-outlets;
- fuse-links;
- fuses;
- special terminals which do not require the removal of a wire.

53-6.2.2.8 All devices used for isolation shall be clearly identified, for example by marking, to indicate the circuit which they isolate.

53-6.3 Switching-off for mechanical maintenance

53-6.3.1 General

53-6.3.1.1 Means of switching-off shall be provided where mechanical maintenance may involve a risk of physical injury.

NOTE 1 Electrically powered mechanical equipment may include rotating machines as well as heating elements and electromagnetic equipment (see SASO…. for electrical installations of machines).

NOTE 2 Examples of installations where means for switching-off for mechanical maintenance are used:

- cranes,
- lifts,
- escalators,
- conveyors,
- machine-tools,
- pumps.

NOTE 3 Systems powered by other means, e.g. pneumatic, hydraulic or steam, are not covered by these rules. In such cases, switching-off any associated supply of electricity may not be a sufficient measure.

53-6.3.1.2 Suitable means shall be provided to prevent electrically powered equipment from becoming unintentionally reactivated during mechanical maintenance, unless the means of switching-off is continuously under the control of any person performing such maintenance.

NOTE Such means may include one or more of the following measures:

- padlocking;
- warning notices;
- location within a lockable space or enclosure.

53-6.3.2 Devices for switching-off for mechanical maintenance

53-6.3.2.1 Devices for switching-off for mechanical maintenance shall be inserted preferably in the main supply circuit.

Where for this purpose switches are provided, they shall be capable of cutting off the full-load current of the relevant part of the installation. They need not necessarily interrupt all live conductors.

Interruption of a control circuit of a drive or the like is permitted only where:

- supplementary safeguards, such as mechanical restrainers, or
- requirements of a relevant specification for the control devices used, provide a condition equivalent to the direct interruption of the main supply.

NOTE Switching-off for mechanical maintenance may be achieved, for example, by means of:

- multipole switches;
- circuit breakers;
- control switches operating contactors;
- plugs and sockets.

53-6.3.2.2 Devices for switching-off for mechanical maintenance or control switches for such devices shall require manual operation.

The clearance between open contacts of the device shall be visible or be clearly and reliably indicated by “off” or “open” marking. Such indication shall only occur when the “off” or “open” position on each pole of the device has been attained.

NOTE The marking required by this statement may be achieved by the use of the symbols “O” and “I” to indicate the open and closed positions respectively.

53-6.3.2.3 Devices for switching-off for mechanical maintenance shall be designed and/or installed so as to prevent unintentional switching on.

NOTE Such switching on might be caused for example by shocks and vibrations.

53-6.3.2.4 Devices for switching-off for mechanical maintenance shall be placed and marked so as to be readily identifiable and convenient for their intended use.

53-6.4 Emergency switching

53-6.4.1 General

NOTE Emergency switching may be emergency switching-on or emergency switching-off.

53-6.4.1.1 Means shall be provided for emergency switching of any part of an installation where it may be necessary to control the supply to remove an unexpected danger.

NOTE Examples of installations where means for emergency switching (apart from emergency stopping in accordance with 53-6.4.1.5) are used:

- pumping facilities for flammable liquids;
- ventilation systems;
- large computers;
- discharge lighting with high-voltage supply, e.g. neon signs;
- certain large buildings, e.g. department stores;
- electrical testing and research facilities;
- teaching laboratories;
- boiler-rooms;
- large kitchens.

53-6.4.1.2 Where a risk of electric shock is involved, the emergency switching device shall cut off all live conductors except as provided in 53-6.1.2.

53-6.4.1.3 Means for emergency switching, including emergency stopping, shall act as directly as possible on the appropriate supply conductors.

The arrangement shall be such that one single action only will cut off the appropriate supply.

53-6.4.1.4 The arrangement of the emergency switching shall be such that its operation does not introduce a further danger or interfere with the complete operation necessary to remove the danger.

NOTE Where this switching includes the function of emergency, in the case of machines, the relevant requirements are specified in SASO IEC 60204-1.

53-6.4.1.5 Means of emergency stopping shall be provided where electrically produced movements may give rise to danger.

NOTE Examples of installations where means for emergency stopping are used:

- escalators;
- lifts;
- elevators;
- conveyors;
- electrically driven doors;
- machine-tools;
- car-washing plants.

53-6.4.2 Devices for emergency switching

53-6.4.2.1 The devices for emergency switching shall be capable of breaking the full-load current of the relevant parts of the installation taking account of stalled motor currents where appropriate.

53-6.4.2.2 Means for emergency switching may consist of:

- one switching device capable of directly cutting off the appropriate supply, or
- a combination of equipment activated by a single action for the purpose of cutting off the appropriate supply.

For emergency stopping, retention of the supply may be necessary, for example, for braking of moving parts.

NOTE Emergency switching may be achieved, for example, by means of:
- switches in the main circuit,
- push-buttons and the like in the control (auxiliary) circuit.

53-6.4.2.3 Hand-operated switching devices for direct interruption of the main circuit shall be selected where practicable.

Circuit-breakers, contactors, etc., operated by remote control shall open on de-energization of coils, or other equivalent failure-to-safety techniques shall be employed.

53-6.4.2.4 The means of operating (handles, push-buttons, etc.) devices for emergency switching shall be clearly identified, preferably colored red with a contrasting background.

53-6.4.2.5 The means of operating shall be readily accessible at places where a danger might occur and, where appropriate, at any additional remote position from which that danger can be removed.

53-6.4.2.6 The means of operation of a device for emergency switching shall be capable of latching or being restrained in the "off" or "stop" position, unless both the means of operation for emergency switching and for re-energizing are under the control of the same person.

The release of an emergency switching device shall not re-energize the relevant part of the installation.

53-6.4.2.7 Devices for emergency switching, including emergency stopping, shall be so placed and marked as to be readily identifiable and convenient for their intended use.

53-6.5 Functional switching (control)

53-6.5.1 General

53-6.5.1.1 A functional switching device shall be provided for each part of a circuit, which may require to be controlled independently of other parts of the installation.

53-6.5.1.2 Functional switching devices need not necessarily control all live conductors of a circuit.

A single-pole switching device shall not be placed in the neutral conductor.

53-6.5.1.3 In general, all current-using apparatus requiring control shall be controlled by an appropriate functional switching device.

A single-functional switching device may control several items of apparatus intended to operate simultaneously.

53-6.5.1.4 Plugs and socket-outlets rated at not more than 16 A may be used for functional switching.

53-6.5.1.5 Functional switching devices ensuring the change-over of supply from alternative sources shall affect all live conductors and shall not be capable of putting the sources in parallel, unless the installation is specifically designed for this condition.

In these cases, no provision is to be made for isolation of the PEN or protective conductors.

53-6.5.2 Functional switching devices

53-6.5.2.1 Functional switching devices shall be suitable for the most onerous duty they may be called upon to perform.

53-6.5.2.2 Functional switching devices may control the current without necessarily opening the corresponding poles.

NOTE 1 Semiconductor switching devices are examples of devices capable of interrupting the current in the circuit but not opening the corresponding poles.

NOTE 2 Functional switching may be achieved, for example by means of:

- switches;
- semiconductor devices;
- circuit-breakers;
- contactors;
- relays;
- plugs and socket-outlets up to 16 A.

53-6.5.2.3 Disconnectors, fuses and links shall not be used for functional switching.

53-6.5.3 Control circuits (auxiliary circuits)

Control circuits shall be designed, arranged and protected to limit dangers resulting from a fault between the control circuit and other conductive parts liable to cause malfunction (e.g. inadvertent operations) of the controlled apparatus.

53-6.5.4 Motor control

53-6.5.4.1 Motor control circuits shall be designed so as to prevent any motor from restarting automatically after a stoppage due to a fall in or loss of voltage, if such starting is liable to cause danger.

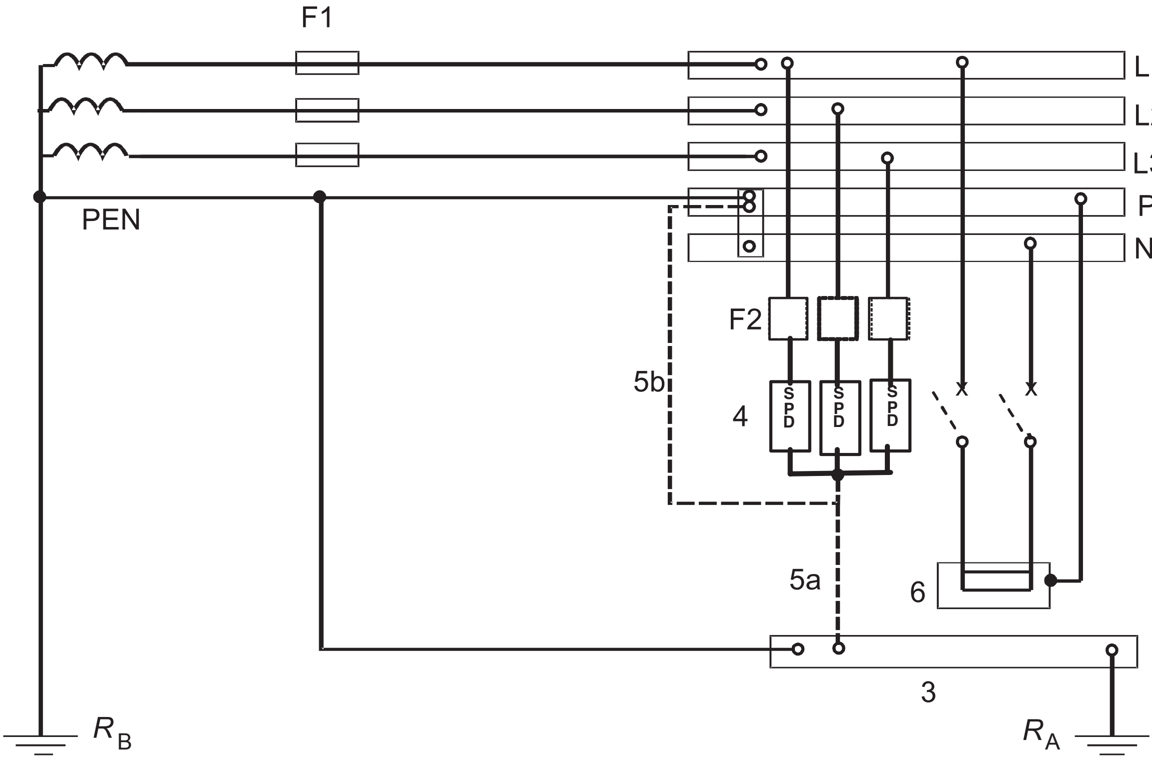
53-6.5.4.2 Where reverse-current braking of a motor is provided, provision shall be made for the avoidance of reversal of the direction of rotation at the end of braking if such reversal may cause danger.

53-6.5.4.3 Where safety depends on the direction of rotation of a motor, provision shall be made for the prevention of reverse operation due to, for example, a reversal of phases.

NOTE Attention is called to danger, which may arise from the loss of one phase.

Annex A.53
(informative)

Installation of Surge Protective Devices in TN Systems

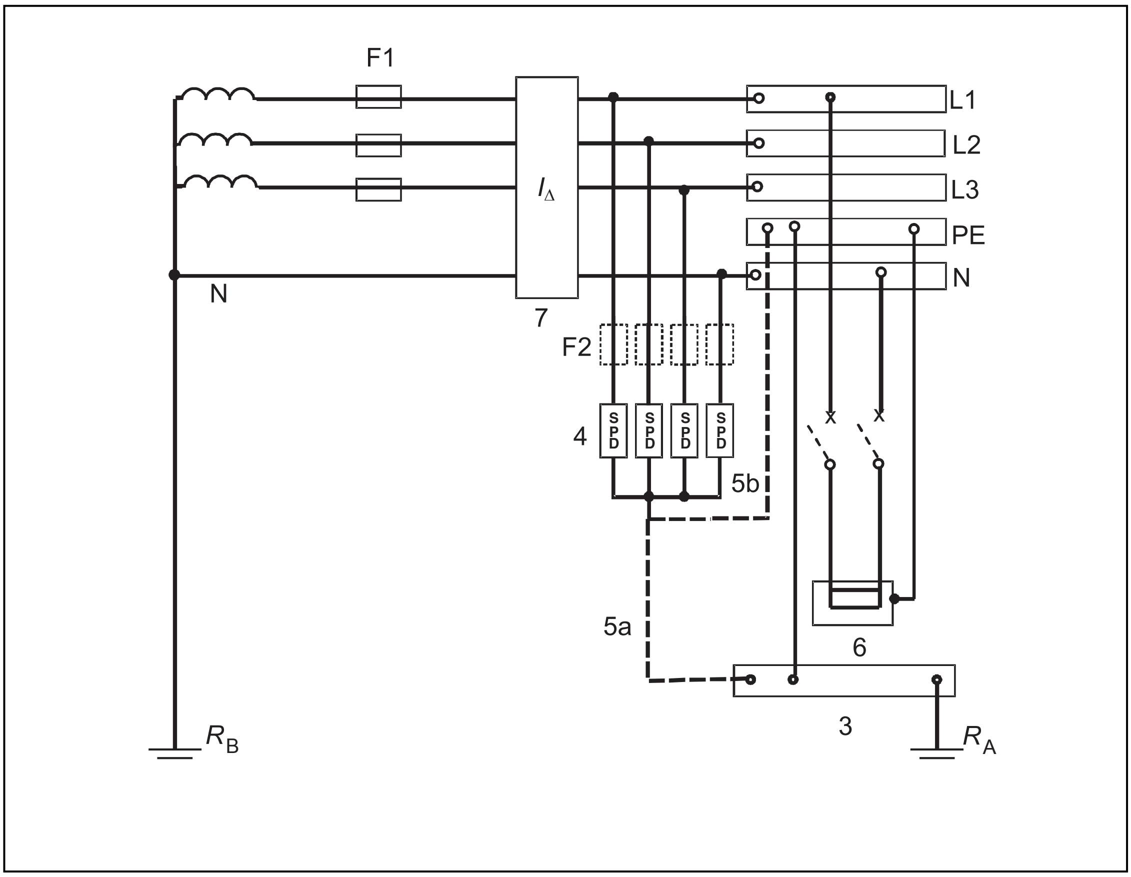


3	Main earthing terminal or bar	F1	Protective device at the origin of the installation
4	Surge protective devices providing protection against overvoltages of category II	F2	Protective device required by the manufacturer of the SPD
5	Earthing connection of surge protective devices, either 5a or 5b	R_A	Earthing electrode (earthing resistance) of the installation
6	Equipment to be protected	R_B	Earthing electrode (earthing resistance) of the supply system

Figure A.53-1 SPDs in TN systems

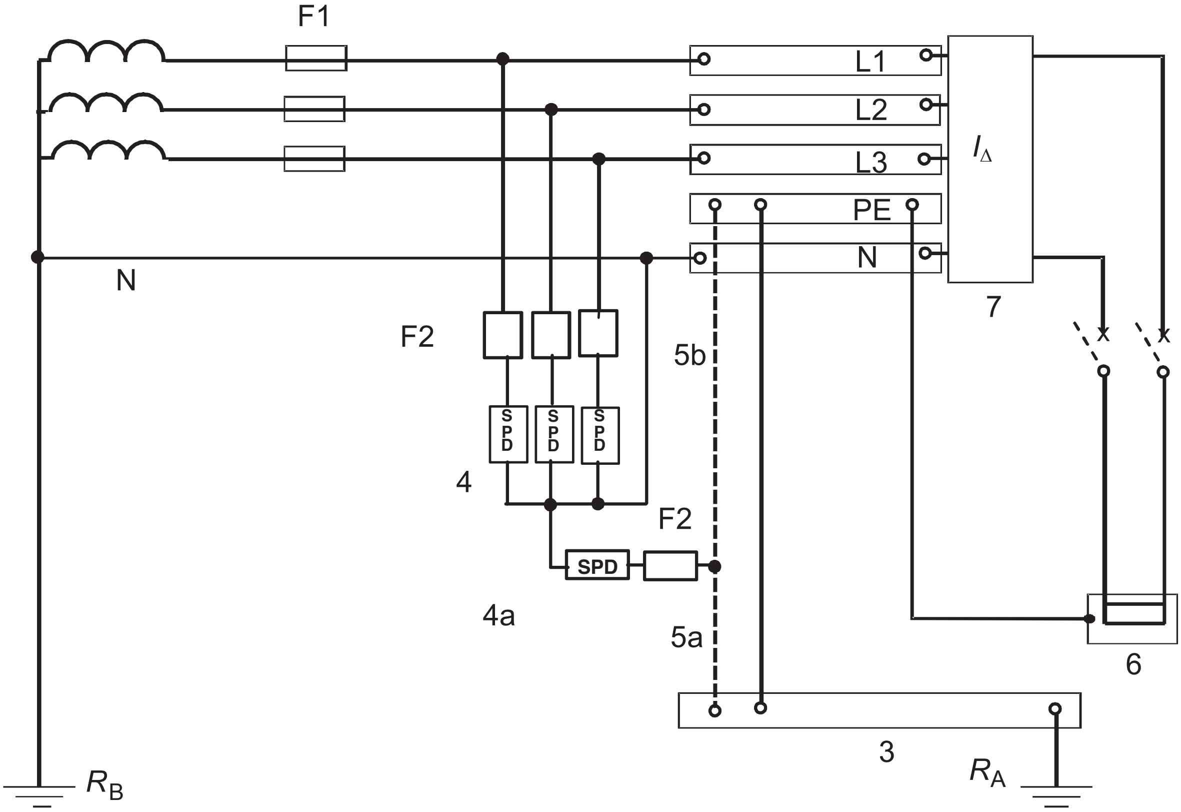
Annex B.53
(informative)

Installation of Surge Protective Devices in TT Systems



3	Main earthing terminal or bar	F1	Protective device at the origin of the installation
4	Surge protective devices providing protection against overvoltages of category II	F2	Protective device required by the manufacturer of the SPD
5	Earthing connection of surge protective devices, either 5a and/or 5b	R_A	Earthing electrode (earthing resistance) of the installation
6	Equipment to be protected	R_B	Earthing electrode (earthing resistance) of the supply system
7	Residual current protective device (RCD)		

Figure B.53-1 SPDs on the load side of a RCD [according to 53-4.2.5 a)]



3 Main earthing terminal or bar

4 Surge protective devices
4a Surge protective device
(a combination 4-4a, providing protection against overvoltages of category II)

5 Earthing connection of surge protective devices, either 5a and/or 5b

6 Equipment to be protected

7 Residual current protective device (RCD), placed either upstream or downstream of the busbars

F1 Protective device at the origin of the installation

F2 Protective device required by the manufacturer of the SPD

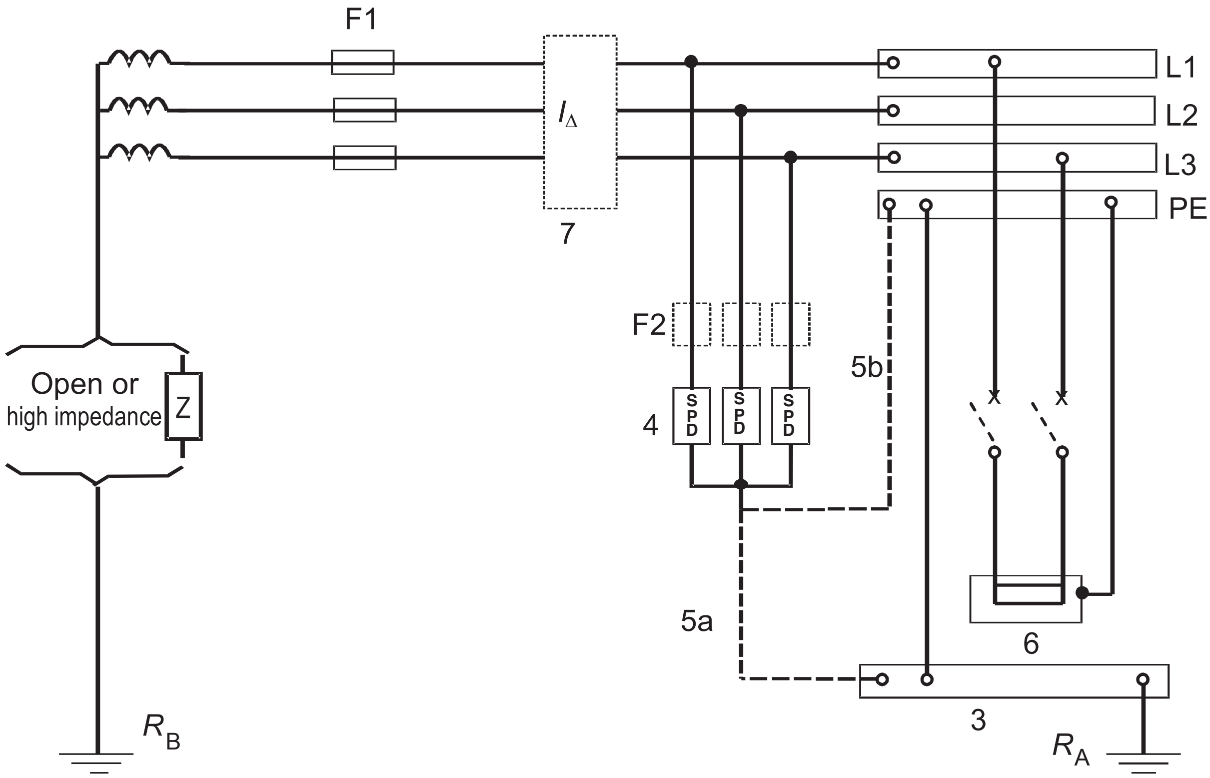
R_A Earthing electrode (earthing resistance) of the installation

R_B Earthing electrode (earthing resistance) of the supply system

Figure B.53-2 SPDs on the supply side of RCD [according to 53-4.2.5 b)]

Annex C.53
(informative)

Installation of Surge Protective Devices in IT Systems

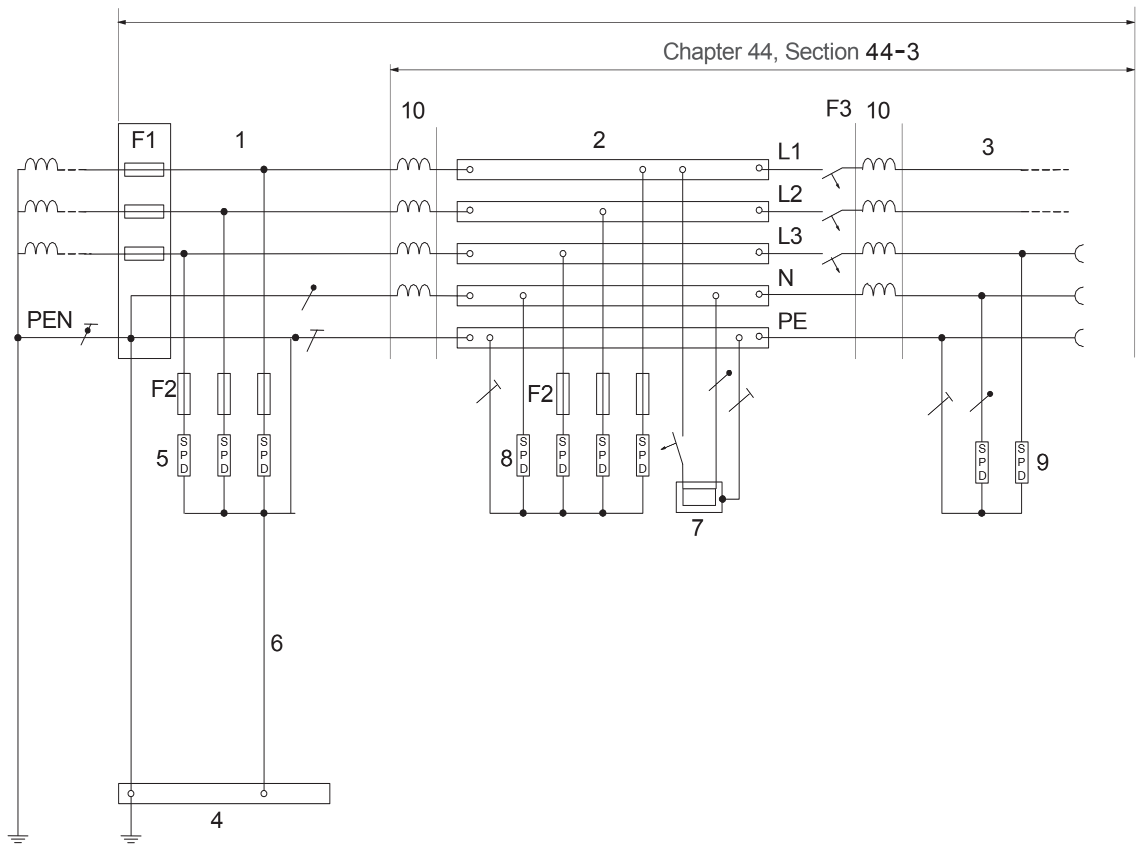


3	Main earthing terminal or bar	F1	Protective device at the origin of the installation
4	Surge protective devices providing protection against overvoltages of category II	F2	Protective device required by the manufacturer of the SPD
5	Earthing connection of surge protective devices, either 5a and/or 5b	R_A	Earthing electrode (earthing resistance) of the installation
6	Equipment to be protected	R_B	Earthing electrode (earthing resistance) of the supply system
7	Residual current protective device (RCD)		

Figure C.53-1 SPDs on the load side of a RCD

Annex D.53
(informative)

Installation of Class I, II and III Tested SPDs for Example in TN-C-S Systems



1 Origin of the installation
2 Distribution board
3 Distribution outlet
4 Main earthing terminal or bar
5 Surge protective device, test class I
6 Earthing connection (earthing conductor) of surge protective device
7 Fixed equipment to be protected
8 Surge protective device, test class II
9 Surge protective device, test class II or III
10 Decoupling element or line length
F1,F2,F3 Overcurrent protective devices

NOTE 1 Reference should be made to SASO IEC 61643-12 for further information.

NOTE 2 SPD 5 and 8 can be combined in a single SPD.

Figure D.53-1 Installation of class I, II and III tested SPDs

CHAPTER 54
EARTHING ARRANGEMENTS, PROTECTIVE CONDUCTORS AND PROTECTIVE BONDING CONDUCTORS

54-0.1 Scope

This Chapter addresses the earthing arrangements, protective conductors and protective bonding conductors in order to satisfy the safety of the electrical installation.

54-2 Earthing arrangements

54-2.1 General requirements

54-2.1.1 The earthing arrangements may be used jointly or separately for protective and functional purposes according to the requirements of the electrical installation. The requirements for protective purposes shall always take precedence.

54-2.1.2 Where provided, earth electrodes within an installation shall be connected to the main earthing terminal using an earthing conductor.

54-2.1.3 Consideration shall be given to the earthing arrangements which are used in high-voltage and low-voltage systems (see 44-2 of Chapter 44).

54-2.1.4 The requirements for earthing arrangements are intended to provide a connection to earth:

- which is reliable and suitable for the protective requirements of the installation;
- which can carry earth fault currents and protective conductor currents to earth without danger from thermal, thermo-mechanical and electromechanical stresses and from electric shock arising from these currents;
- which, if relevant, is also suitable for functional requirements.

54-2.2 Earth electrodes

54-2.2.1 Materials and dimensions of the earth electrodes shall be selected to withstand corrosion and to have adequate mechanical strength.

For commonly used materials, the common minimum sizes from the point of view of corrosion and mechanical strength for earth electrodes where embedded in the soil are given in table 54-1.

NOTE If a lightning protection system (LPS) is present, 802.4.2 is applied.

Table 54-1 Common minimum sizes for earth electrodes of commonly used material from the point of view of corrosion and mechanical strength where embedded in the soil

Material	Surface	Shape	Minimum size				
			Diameter mm	Cross-sectional area mm^2	Thickness mm	Thickness of coating/sheathing: Individual value m	Thickness of coating/sheathing: Average value m
Steel	Hot-dip galvanized [a] or Stainless [a, b]	Strip [c]		90	3	63	70
		Sections		90	3	63	70
		Round rod for deep earth electrodes	16			63	70
		Round wire for surface electrode [g]	10				50 [e]
		Pipe	25		2	47	55
	Copper-sheathed	Round rod for deep earth electrode	15			2 000	
	With electro-deposited copper coating	Round rod for deep earth electrode	14			90	100
Copper	Bare [a]	Strip		50	2		
		Round wire for surface electrode [g]		25 [f]			
		Rope	1.8 for individual strands of wire	25			
		Pipe	20		2		
	Tin-coated	Rope	1.8 for individual strands of wire	25		1	5
	Zinc-coated	Strip [d]		50	2	20	40

[a] Can also be used for electrodes to be embedded in concrete.

[b] No coating applied.

[c] As rolled strip or slit strip with rounded edges.

[d] Strip with rounded edges.

[e] In the case of continuous bath-coating, only 50 m thickness is technically feasible at present.

[f] Where experience shows that the risk of corrosion and mechanical damage is extremely low, 16 mm^2 can be used.

[g] An earth electrode is considered to be a surface electrode when installed at a depth not exceeding 0.5 m.

54-2.2.2 The efficacy of any earth electrode depends upon local soil conditions. One or more earth electrodes suitable for the soil conditions and the value of resistance to earth required, shall be selected.

54-2.2.3 The following are examples of earth electrodes which may be used:

- underground structural networks embedded in foundations (foundation earthing);
- plates;
- metal reinforcement of concrete (except prestressed concrete) embedded in the earth;
- rods or pipes;
- tapes or wires;
- other suitable underground metalwork according to local conditions or requirements.

The design used, and the construction of an earth electrode shall be such as to withstand damage and to take account of possible increase in resistance due to corrosion.

54-2.2.4 When selecting type and embedded earth electrode, consideration shall be given to soil pH values to increase long lasting the integrity of the earth system.

54-2.2.5 Consideration shall be given to electrolytic corrosion when using different materials in an earthing arrangement.

54-2.2.6 A metallic pipe for flammable liquids or gases shall not be used as an earth electrode.

NOTE This requirement does not preclude the protective bonding of such pipes for compliance with Chapter 41.

54-2.3 Earthing conductors

54-2.3.1 Earthing conductors shall comply with 54-3.1 and where buried in the soil, their cross-sectional areas shall be in accordance with Table 54.2.

In TN systems, where no noticeable fault current is expected to pass in the earth electrode, the earthing conductor may be dimensioned according to 54-4.1.1.

Table 54.2 Minimum cross-sectional areas of earthing conductors buried in the soil

	Mechanically protected	Mechanically unprotected
Protected against corrosion	2.5 mm^2 Copper 10 mm^2 Steel	16 mm^2 Copper 16 mm^2 Steel
Not protected against corrosion	25 mm^2 Copper 50 mm^2 Steel	

54-2.3.2 The connection of an earthing conductor to an earth electrode shall be soundly made and electrically satisfactory. The connection shall be by exothermic welding, pressure connectors, clamps or other mechanical connectors. Mechanical connectors shall be installed in accordance with the manufacturer's instructions. Where a clamp is used, it shall not damage the electrode or the earthing conductor.

NOTE Connection devices or fittings that depend solely on solder, do not reliably provide adequate mechanical strength.

54-2.4 Main earthing terminal

54-2.4.1 In every installation where protective bonding is used, a main earthing terminal shall be provided and the following shall be connected to it:

- protective bonding conductors;
- earthing conductors;
- protective conductors;
- functional earthing conductors, if relevant.

NOTE 1 It is not intended to connect every individual protective conductor directly to the main earthing terminal when they are connected to this terminal by other protective conductors.

NOTE 2 The main earthing terminal of the building can generally be used for functional earthing purposes. For information technology purposes, it is then regarded as the connection point to the earth electrode network.

54-2.4.2 Each conductor connected to the main earthing terminal shall be able to be disconnected individually. This connection shall be reliable and disconnectable only by means of a tool.

NOTE Disconnection means may conveniently be combined with the main earthing terminal, to permit measurement of the resistance of the earthing arrangements.

54-3 Protective conductors

54-3.1 Minimum cross-sectional areas

54-3.1.1 The cross-sectional area of every protective conductor shall satisfy the conditions for automatic disconnection of supply required in 41-3.1 of Chapter 41 and be capable of withstanding the prospective fault current.

The cross-sectional area of the protective conductor shall either be calculated in accordance with 54-3.1.2, or selected in accordance with Table 54-3. In either case, the requirements of 54-3.1.3 shall be taken into account.

Terminals for protective conductors shall be capable of accepting conductors of dimensions required by this statement.

Table 54-3 Minimum cross-sectional area of protective conductors

Cross-sectional area of line conductor *S* mm²	**Minimum cross-sectional area of the corresponding protective conductor** mm²	
	If the protective conductor is of the same material as the line conductor	**If the protective conductor is not of the same material as the line conductor**
$S \leq 16$	S	$\frac{k_1}{k_2} \times S$
$16 < S \leq 35$	16 [a]	$\frac{k_1}{k_2} \times 16$
$S > 35$	$\frac{S}{2}$ [a]	$\frac{k_1}{k_2} \times \frac{S}{2}$

Where
k_1 is the value of k for the line conductor, selected from Table A.54-1 or from the tables in Chapter 43, according to the materials of the conductor and insulation;
k_2 is the value of k for the protective conductor, selected from Tables A.54-2 to A.54-6 as applicable.

[a] For a PEN conductor, the reduction of the cross-sectional area is permitted only in accordance with the rules for sizing of the neutral conductor (see Chapter 52).

54-3.1.2 The cross-sectional areas of protective conductors shall not be less than the value determined either:

- in accordance with SASO IEC 60949.
- or by the following formula applicable only for disconnection times not exceeding 5 s:

$$S = \frac{\sqrt{I^2 t}}{k}$$

Where

S is the cross-sectional area, in mm^2;

I is the value (r.m.s) in A of prospective fault current for a fault of negligible impedance, which can flow through the protective device (see SASO IEC 60909-0);

t is the operating time of the protective device for automatic disconnection in s;

NOTE 1 Account should be taken of the current-limiting effect of the circuit impedances and the limitation of I^2t of the protective device.

k is the factor dependent on the material of the protective conductor, the insulation and other parts and the initial and the final temperatures (for calculation of k, see Annex A.54).

If application of the formula produces non-standard sizes, conductors of a higher standard cross-sectional area shall be used.

NOTE 2 For limitations of temperatures for installations in potentially explosive atmospheres, see SASO IEC 60079-0 and chapter 720.

NOTE 3 As the metallic sheaths of mineral insulated cables according to SASO IEC 60702-1 have an earth fault capacity greater than that of the line conductors, it is not necessary to calculate the cross-sectional area of the metallic sheaths when used as protective conductors.

54-3.1.3 The cross-sectional area of every protective conductor which does not form part of the cable or which is not in a common enclosure with the line conductor shall be not less than:

- 2.5 mm^2 Cu/16 mm^2 Al if protection against mechanical damage is provided,
- 4 mm^2 Cu/16 mm^2 Al if protection against mechanical damage is not provided.

54-3.1.4 Where a protective conductor is common to two or more circuits, its cross-sectional area shall be dimensioned as follows:

- calculated in accordance with 54-3.1.1 for the most onerous prospective fault current and operating time encountered in these circuits; or
- selected in accordance with Table 54-3 so as to correspond to the cross-sectional area of the largest line conductor of the circuits.

54-3.2 Types of protective conductors

54-3.2.1 Protective conductors may consist of one or more of the following:

- conductors in multicore cables;
- insulated or bare conductors in a common enclosure with live conductors;
- fixed installed bare or insulated conductors;
- metallic cable sheath, cable screen, cable armour, wirebraid, concentric conductor, metallic conduit, subject to the conditions stated in 54-3.2.2 a) and b);
- Cable tray and cable ladder are permitted as protective conductor.

NOTE See 54-3.6 for their arrangement.

54-3.2.2 Where the installation contains equipment having metal enclosures such as low-voltage switchgear and controlgear assemblies or busbar trunking systems, the metal enclosures or frames may be used as protective conductors if they simultaneously satisfy the following three requirements:

a) their electrical continuity shall be assured by construction or by suitable connection so as to ensure protection against mechanical, chemical or electrochemical deterioration;

b) they comply with the requirement of 54-3.1;

c) they shall permit the connection of other protective conductors at every predetermined tap off point.

54-3.2.3 The following metal parts are not permitted for use as protective conductor or as protective bonding conductors:

- metallic water pipes;
- pipes containing flammable gases or liquids;
- constructional parts subject to mechanical stress in normal service;
- flexible or pliable metal conduits, unless designed for that purpose;
- flexible metal parts;
- support wires.

54-3.3 Electrical continuity of protective conductors

54-3.3.1 Protective conductors shall be suitably protected against mechanical damage, chemical or electrochemical deterioration, electrodynamic forces and thermodynamic forces.

54-3.3.2 Joints in protective conductors shall be accessible for inspection and testing except for

- compound-filled joints,
- encapsulated joints,
- joints in metal conduits and trunking,
- joints forming part of equipment, complying with equipment standards.

54-3.3.3 No switching device shall be inserted in the protective conductor, but joints, which can be disconnected for test purposes by use of a tool may be provided.

54-3.3.4 Where electrical monitoring of earthing is used, no dedicated devices (e.g. operating sensors, coils) shall be connected in series in protective conductors.

54-3.3.5 Exposed-conductive-parts of apparatus shall not be used to form part of the protective conductor for other equipment except as allowed by 54-3.2.2.

54-3.4 PEN conductors

54-3.4.1 A PEN conductor may only be used in fixed electrical installations and, for mechanical reasons, shall have a cross-sectional area not less than 10 mm^2 in copper or 16 mm^2 in aluminium.

54-3.4.2 The PEN conductor shall be insulated for the highest voltage to which it may be subjected.

54-3.4.3 If, from any point of the installation, the neutral and protective functions are provided by separate conductors, it is not permitted to connect the neutral conductor to any other earthed part of the installation (e.g. protective conductor from the PEN conductor). However, it is permitted to form more than one neutral conductor and more than one protective conductor from the PEN conductor. Separate terminals or bars may be provided for the protective and neutral conductors. In this case, the PEN conductor shall be connected to the terminal or bar intended for the protective conductor.

54-3.4.4 Extraneous-conductive-parts shall not be used as PEN conductors.

54-3.5 Combined protective and functional earthing

54-3.5.1 Where a combined protective and functional earthing conductor is used, it shall satisfy the requirements for a protective conductor. In addition, it shall also comply with the relevant functional requirements (see 44-4 of Chapter 44).

A d.c. return conductor PEL or PEM, for an information technology power supply, may also serve as a combined functional earthing and protective conductor.

54-3.5.2 Extraneous-conductive-parts shall not be used as PEL or PEM.

54-3.6 Arrangement of protective conductors

When overcurrent protective devices are used for protection against electric shock, the protective conductor shall be incorporated in the same wiring system as the live conductors or be located in their immediate proximity.

54-3.7 Reinforced protective conductors for protective conductor currents exceeding 10 mA

For current using equipment intended for permanent connection and with a protective conductor current exceeding 10 mA, reinforced protective conductors shall be designed as follows:

- either the protective conductor shall have a cross-sectional area of at least 10 mm^2 Cu or 16 mm^2 Al, through its total run;

  NOTE 1 PEN conductor in accordance with 54-3.4 complies with this requirement.

- or a second protective conductor of at least the same cross-sectional area as required for protection against indirect contact shall be laid up to a point where the protective conductor has a cross-sectional area not less than 10 mm^2 Cu or 16 mm^2 Al. This requires that the appliance has a separate terminal for a second protective conductor.

  NOTE 2 In TN-C systems where the neutral and protective conductors are combined in a single conductor (PEN conductor) up to the equipment terminals, protective conductor current may be treated as load current.

  NOTE 3 Current-using equipment, normally having high protective conductor current may not be compatible with installations incorporating residual current protective devices.

54-4 Protective bonding conductors (equipotential bonding conductors)

54-4.1 Protective bonding conductors for the connection to the main earthing terminal

54-4.1.1 The cross-sectional area of protective bonding conductors which are provided for the main equipotential bonding according to 41-3.1.2.1 of Chapter 41 and which are connected to the main earthing terminal according to 54-2.4 shall not be less than:

- 6 mm^2 copper; or
- 16 mm^2 aluminium; or
- 50 mm^2 steel.

54-4.2 Protective bonding conductors for supplementary bonding

54-4.2.1 A protective bonding conductor connecting two exposed-conductive-parts shall have a conductance not less than that of the smaller protective conductor connected to the exposed conductive parts.

54-4.2.2 A protective bonding conductor connecting exposed-conductive-parts to extraneous-conductive-parts shall have a conductance not less than half of that of the cross-sectional area of the corresponding protective conductor.

54-4.2.3 Sub-sub-section 54-3.1.3 shall be complied with.

Annex A.54
(normative)

Method for Deriving the Factor *k* in 54-3.1.2

The factor *k* is determined from the following formula:

$$k = \sqrt{\frac{Q_c(\beta + 20\,°C)}{\rho_{20}} \ln\left(1 + \frac{\theta_f - \theta_i}{\beta + \theta_i}\right)}$$

Where

Q_c is the volumetric heat capacity of conductor material (J/°C mm^3) at 20°C;

β is the reciprocal of temperature coefficient of resistivity at 0°C for the conductor (°C);

ρ_{20} is the electrical resistivity of conductor material at 20°C (Ω mm);

θ_i initial temperature of conductor (°C);

θ_f final temperature of conductor (°C).

Table A.54-1 Value of parameters for different materials

Material	β °C	Q_c J/°C mm^3	ρ_{20} Ω mm	$\sqrt{\frac{Qc(\beta + 20°C)}{\rho_{20}}}$ $A\sqrt{s}/mm^2$
Copper	234.5	3.45×10^{-3}	17.241×10^{-6}	226
Aluminium	228	2.5×10^{-3}	28.264×10^{-6}	148
Lead	230	1.45×10^{-3}	214×10^{-6}	41
Steel	202	3.8×10^{-3}	138×10^{-6}	78

Table A.54-2 Values of *k* for insulated protective conductors not incorporated in cables and not bunched with other cables

Conductor insulation	Temperature °C [b]		Material of conductor		
			Copper	Aluminium	Steel
	Initial	Final	Values for *k* [c]		
70°C PVC	30	160/140 [a]	143/133 [a]	95/88 [a]	52/49 [a]
90°C PVC	30	160/140 [a]	143/133 [a]	95/88 [a]	52/49 [a]
90°C thermosetting	30	250	176	116	64
60°C rubber	30	200	159	105	58
85°C rubber	30	220	166	110	60
Silicone rubber	30	350	201	133	73

[a] The lower value applies to PVC insulated conductors of cross-sectional area greater than 300 mm^2.

[b] Temperature limits for various types of insulation are given in SASO IEC 60724.

[c] For the method of calculating *k*, see the formula at the beginning of this Annex.

Table A.54-3 Values of *k* for bare protective conductors in contact with cable covering but not bunched with other cables

Cable covering	Temperature °C [a]		Material of conductor		
			Copper	Aluminium	Steel
	Initial	Final	Values for *k* [b]		
PVC	30	200	159	105	58
Polyethylene	30	150	138	91	50
CSP	30	220	166	110	60

[a] Temperature limits for various types of insulation are given in SASO IEC 60724.

[b] For the method of calculating *k*, see the formula at the beginning of this Annex.

Table A.54-4 Values of *k* for protective conductors as a core incorporated in a cable or bunched with other cables or insulated conductors

Conductor insulation	Temperature °C [b]		Material of conductor		
			Copper	Aluminium	Steel
	Initial	Final	Values for *k* [c]		
70°C PVC	70	160/140 [a]	115/103 [a]	76/68 [a]	42/37 [a]
90°C PVC	90	160/140 [a]	100/86 [a]	66/57 [a]	36/31 [a]
90°C thermosetting	90	250	143	94	52
60°C rubber	60	200	141	93	51
85°C rubber	85	220	134	89	48
Silicone rubber	180	350	132	87	47

[a] The lower value applies to PVC insulated conductors of cross-sectional area greater than 300 mm^2.

[b] Temperature limits for various types of insulation are given in SASO IEC 60724.

[c] For the method of calculating *k*, see the formula at the beginning of this Annex.

Table A.54-5 Values of *k* for protective conductors as a metallic layer of a cable e.g. armour, metallic sheath, concentric conductor, etc.

Cable insulation	Temperature °C [a]		Material of conductor			
			Copper	Aluminium	Lead	Steel
	Initial	Final	Values for *k* [c]			
70°C PVC	60	200	141	93	26	51
90°C PVC	80	200	128	85	23	46
90°C thermosetting	80	200	128	85	23	46
60°C rubber	55	200	144	95	26	52
85°C rubber	75	220	140	93	26	51
Mineral PVC covered [b]	70	200	135	–	–	–
Mineral bare sheath	105	250	135	–	–	–

[a] Temperature limits for various types of insulation are given in SASO IEC 60724.

[b] This value shall also be used for bare conductors exposed to touch or in contact with combustible material.

[c] For the method of calculating *k*, see the formula at the beginning of this Annex.

Table A.54-6 Value of *k* for bare conductors where there is no risk of damage to any neighbouring material by the temperature indicated

		Material of conductor					
		Copper		Aluminium		Steel	
Conditions	Initial temperature °C	*k* value	Maximum temperature °C	*k* value	Maximum temperature °C	*k* value	Maximum temperature °C
Visible and in restricted area	30	228	500	125	300	82	500
Normal conditions	30	159	200	105	200	58	200
Fire risk	30	138	150	91	150	50	150

Annex B.54
(informative)

Illustration of Earthing Arrangements, Protective Conductors and Protective Bonding Conductors

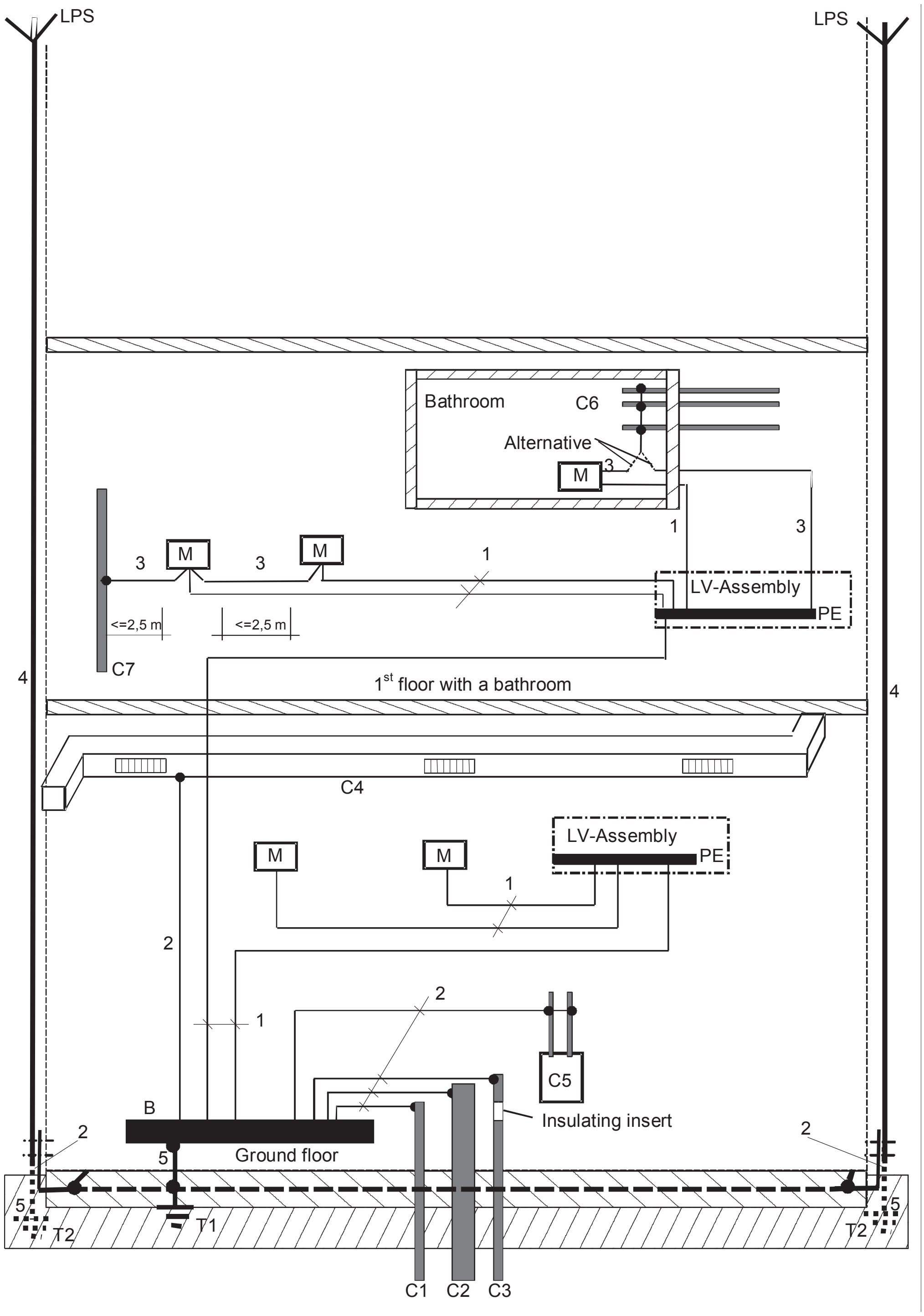


Figure B.54-1 Earthing arrangements, protective conductors and protective bonding conductors

Key

M Exposed-conductive-part
conductive part of equipment which can be touched and which is not normally live, but which can become live when basic insulation fails

C Extraneous-conductive-part
conductive part not forming part of the electrical installation and liable to introduce an electric potential, generally the electric potential of a local earth

C1 Waterpipe, metal from outside
C2 Waste, water, metal from outside
C3 Gas pipe with insulating inset, metal from outside
C4 Air-conditioning
C5 Heating-system
C6 Waterpipe, metal e.g. in a bathroom
C7 Extraneous-conductive-parts in arm's reach of exposed-conductive-parts

B Main earthing terminal (main earthing busbar)
terminal or busbar which is part of the earthing arrangement of an installation and enabling the electric connection of a number of conductors for earthing purposes

T Earth electrode
conductive part, which may be embedded in a specific conductive medium, e.g. concrete or coke, in electric contact with the earth

T1 Foundation earth
T2 Earth electrode for LPS if necessary

1 Protective conductor
conductor provided for purposes of safety, for example protection against electric shock

2 Protective bonding conductor
protective conductor provided for protective-equipotential-bonding

3 Protective bonding conductor for supplementary bonding
4 Down conductor of a lightning protection system (LPS)
5 Earthing conductor
conductor which provides a conductive path, or part of the conductive path, between a given point in a system or in an installation or in equipment and an earth electrode

NOTE For the purpose of these Electrical Requirements, an earthing conductor is the conductor, which connects the earth electrode to a point of the common equipotential bonding system, usually the main earthing terminal.

CHAPTER 55
OTHER EQUIPMENT

55-0.1 Scope

This chapter covers requirements for low-voltage generating sets. Particular requirements for supplies for safety services are given in 55-6.

Electrical standby supply systems, other than for safety services, are outside the scope of these Electrical Requirements.

This chapter does not apply for installations in hazardous areas (BE3).

NOTE 1 Requirements of the public supply undertaking should be ascertained before a generating set is installed in an installation, which is connected to the public supply.

NOTE 2 For additional requirements for hazardous areas, see the chapters 720, 721, 722, 723, 724 and 725 or SASO IEC 60079 and SASO IEC 61241 series.

55-1 Low-voltage generating set

55-1.1 Scope

This section applies to low-voltage and extra-low-voltage installations, which incorporate generating sets intended to supply, either continuously or occasionally, all or part of the installation. Requirements are included for installation with the following supply arrangements:

- supply to an installation which is not connected to the public supply;
- supply to an installation as an alternative to the public supply;
- supply to an installation in parallel with the public supply;
- appropriate combinations of the above.

This section does not apply to self-contained items of extra-low-voltage electrical equipment, which incorporate both the source of energy and the energy-using load and for which a specific product standard exists that includes the requirements for electrical safety.

55-1.1.1 Generating sets with the following power sources are considered:

- combustion engines;
- turbines;
- electric motors;
- photovoltaic cells;
- electrochemical accumulators;
- other suitable sources.

55-1.1.2 Generating sets with the following electrical characteristics are considered:

- mains-excited and separately excited synchronous generators;
- mains-excited and self-excited asynchronous generators;
- mains-commutated and self-commutated static inverters with or without by-pass facilities.

55-1.1.3 The use of generating sets for the following purposes is considered:

- supply to permanent installations;
- supply to temporary installations;
- supply to portable equipment which is not connected to a permanent fixed installation.

55-1.2 General requirements

55-1.2.1 The means of excitation and commutation shall be appropriate for the intended use of the generating set and the safety and proper functioning of other sources of supply shall not be impaired by the generating set.

NOTE See 55-1.7 for particular requirements where the generating set may operate in parallel with a public supply.

55-1.2.2 The prospective short-circuit current and prospective earth fault current shall be assessed for each source of supply or combination of sources which can operate independently of other sources or combinations. The short-circuit rating of protective devices within the installation and, where appropriate, connected to the public supply network, shall not be exceeded for any of the intended methods of operation of the sources.

55-1.2.3 Where the generating set is intended to provide a supply to an installation which is not connected to the public supply or to provide a supply as a switched alternative to the public supply, the capacity and operating characteristics of the generating set shall be such that danger or damage to equipment does not arise after the connection or disconnection of any intended load as a result of the deviation of the voltage or frequency from the intended operating range. Means shall be provided to automatically disconnect such parts of the installation as may be necessary if the capacity of the generating set is exceeded.

NOTE 1 Attention should be given to the size of individual loads as a proportion of the capacity of the generating set and to motor starting currents.

NOTE 2 Attention should be given to the power factor specified for protective devices in the installation.

NOTE 3 The installation of a generating set within an existing building or installation may change the conditions of external influence for the installation (see Chapter 51), for example by the introduction of moving parts, parts at high temperature or by the presence of noxious gases, etc.

55-1.3 Protection against both direct and indirect contact

Additional requirements for extra-low-voltage (ELV) systems, which provide protection against both direct and indirect contact and where the installation is supplied from more than one source.

55-1.3.1 Where a SELV of PELV system may be supplied by more than one source, the requirements of 41-1.1.2 of Chapter 41 shall apply to each source. Where one or more of the sources is earthed, the requirements of 41-1.1.3 and 41-1.1.5 of Chapter 41 for PELV systems shall apply.

If one or more of the sources does not meet the requirements of 41-1.1.2 of Chapter 41, the system shall be treated as a FELV system and the requirements of 41-1.3 shall apply.

55-1.3.2 Where it is necessary to maintain the supply to an extra-low-voltage system following the loss of one or more sources of supply, each source of supply or combination of sources of supply, which can operate independently of other sources or combinations shall be capable of supplying the intended load of the extra-low-voltage system. Provisions shall be made so that the loss of low-voltage supply to an extra-low-voltage source does not lead to danger or damage for other extra-low-voltage equipment.

NOTE Such precautions may be necessary in supplies for safety services (see PART THREE).

55-1.4 Protection against indirect contact

Protection against indirect contact shall be provided for the installation in respect of each source of supply or combination of sources of supply, which can operate independently of other sources or combinations of sources.

55-1.4.1 Protection by automatic disconnection of supply

Protection by automatic disconnection of supply shall be provided in accordance with 41-3.1 of Chapter 41, except as modified for particular cases by 55-1.4.2, 55-1.4.3 or 55-1.4.4.

55-1.4.2 Additional requirements for installations where the generating set provides a switched alternative to the public supply (standby systems)

Protection by automatic disconnection of supply shall not rely upon the connection to the earthed point of the public supply system when the generator is operating as a switched alternative to a TN system. A suitable earth electrode shall be provided.

55-1.4.3 Additional requirements for installations incorporating static inverters

55-1.4.3.1 Where protection against indirect contact for parts of the installation supplied by the static inverter relies upon the automatic closure of the by-pass switch and the operation of protective devices on the supply side of the by-pass switch is not within the time required by 41-3.1 of Chapter 41, supplementary equipotential bonding shall be provided between simultaneous accessible exposed conductive parts and extraneous conductive parts on the load side of the static inverter in accordance with 41-3.1.6 of Chapter 41.

The resistance of supplementary equipotential bonding conductors required between simultaneously accessible conductive parts shall fulfill the following condition:

$$R \leq \frac{50}{I_a}$$

Where

I_a Is the maximum earth fault current, which can be supplied by the static inverter alone for a period of up to 5 s.

NOTE Where such equipment is intended to operate in parallel with a public supply system, the requirements of 55-1.7 also apply.

55-1.4.3.2 Precautions shall be taken or equipment shall be selected so that the correct operation of protective devices is not impaired by d.c. currents generated by a static inverter or by the presence of filters.

55-1.4.4 Additional requirements for protection by automatic disconnection where the installation and generating set are not permanently fixed

This sub-sub-section applies to portable generating sets and to generating sets, which are intended to be moved to unspecified locations for temporary or short-term use. Such generating sets may be part of an installation, which is subject to similar use. This statement does not apply to permanent fixed installations.

NOTE For suitable connection arrangements see SASO IEC 60309.

55-1.4.4.1 Between separate items of equipment protective conductors shall be provided which, are part of a suitable cord or cable and which comply with Table 54-3 of Chapter 54. All protective conductors shall comply with Chapter 54.

55-1.4.4.2 In TN, TT and IT systems a residual current protective device with a rated residual operating current of not more than 30 mA shall be installed in accordance with 41-3.1 of Chapter 41 to provide automatic disconnection.

NOTE In IT systems, a residual current device may not operate unless one of the earth faults is on a part of the system on the supply side of the device.

55-1.5 Protection against overcurrent

55-1.5.1 Where means of detecting overcurrent of the generating set is provided, this shall be located as near as practicable to the generator terminals.

NOTE The contribution to the prospective short-circuit current by a generating set may be time-dependent and may be much less than the contribution made by a public supply.

55-1.5.2 Where a generating set is intended to operate in parallel with a public supply, or where two or more generating sets may operate in parallel, circulating harmonic currents shall be limited so that the thermal rating of conductors is not exceeded.

The effects of circulating harmonic currents may be limited as follows:

- the selection of generating sets with compensated windings;
- the provision of a suitable impedance in the connection to generator star points;
- the provision of switches which interrupt the circulatory circuit but which are interlocked so that at all times protection against indirect contact is not impaired;
- the provision of filtering equipment;
- other suitable means.

NOTE Consideration should be given to the maximum voltage, which may be produced across an impedance connected to limit circulating harmonics.

55-1.6 Additional requirements for installations where the generating set provides a supply as a switched alternative to the public supply (standby systems)

55-1.6.1 Precautions complying with the relevant requirements of Chapter 53 for isolation shall be taken, so that the generator cannot operate in parallel with the public supply system. Suitable precautions may include:

- an electrical, mechanical or electro-mechanical interlock between the operating mechanisms or control circuits of the change-over switching devices;
- a system of locks with a single transferable key;
- a three-position break-before-make change-over switch;
- an automatic change-over switching device with a suitable interlock;
- other means providing equivalent security of operation.

55-1.6.2 For TN-S systems where the neutral is not isolated, any residual current device shall be positioned to avoid incorrect operation due to the existence of any parallel neutral-earth path.

NOTE It may be desirable in TN systems to disconnect the neutral of the installation from the public supply system to avoid disturbances such as induced voltage surges caused by lightning.

55-1.7 Additional requirements for installations where the generating set may operate in parallel with the public supply system

55-1.7.1 In selecting and using a generating set to run in parallel with a public supply, care shall be taken to avoid adverse effects to the supply network and to other installations in respect of power factor, voltage changes, harmonic distortion, unbalance, starting, synchronizing or voltage fluctuation effects. The public supply undertaking shall be consulted in respect of particular requirements. Where synchronization is necessary, the use of automatic synchronizing systems, which consider frequency, phase and voltage, is to be preferred.

55-1.7.2 Protection shall be provided to disconnect the generating set from the public supply in the event of loss of that supply or deviation of the voltage or frequency at the supply terminals from values declared for normal supply.

The type of protection and the sensitivity and operating times depend upon the protection of the public supply system and shall be agreed by the public supply undertaking.

55-1.7.3 Means shall be provided to prevent the connection of a generating set to the public supply system if the voltage and frequency of the public supply are outside the limits of operation of the protection required in 55-1.7.2.

55-1.7.4 Means shall be provided to enable the generating set to be isolated from the public supply. The means of isolation shall be accessible to the public supply undertaking at all times.

55-1.7.5 Where a generating set may also operate as switched alternative to the public supply, the installation shall also comply with 55-1.6.

55-6 Safety services

55-6.1 General requirements

55-6.1.1 Safety services required to operate in fire conditions shall meet the following requirements:

- a safety source shall maintain an electrical supply of a duration of not less 90 minutes;
- equipment shall have a fire resistance of a duration of not less 2 hours by suitable selection or erection.

NOTE 1 Two types of electrical supply source may exist: the safety source and the normal source.

NOTE 2 The normal source is, for example, the public supply network.

55-6.1.2 For protection against indirect contact, protective measures without automatic disconnection at the first fault are preferred.

In IT systems, continuous insulation monitoring devices shall be provided to give an audible and visible indication of a first fault to earth.

55-6.2 Supplies to current-using equipment

Where electrical equipment is supplied by two different sources, a failure occurring in the circuit from one source shall not impair the protection against electric shock or the correct operation of the other source. Where such equipment requires a protective conductor, it shall be connected to the protective conductors of both circuits.

55-6.3 Special requirements

55-6.3.1 Protection against short-circuits and against electric shock, under normal conditions and in case of a fault, shall be ensured under any configuration of the normal and safety sources of supply.

55-6.3.2 Protection against overload may be omitted where the loss of supply may cause a greater hazard. Where protection against overload is omitted, the occurrence of an overload shall be monitored.

55-6.3.3 Depending on whether the safety source is to operate in parallel with or independently of the normal supply, the appropriate sub-sections of 55-1 shall be taken into account.

55-6.4 Switchgear and controlgear

55-6.4.1 Switchgear and controlgear shall be provided, either by construction, location or erection, with protection ensuring fire resistance of a duration of not less than 2 hours.

55-6.4.2 Controlgear shall not influence the operation of safety services, at any time when called upon to operate. The position of switching devices, whose operation could cause a hazard, shall be clearly and visibly indicated.

55-6.4.3 Switchgear and controlgear for the supply of safety service installations shall be physically separated from components of the normal supply installation.

55-6.4.4 Switchgear and controlgear, including safety lighting controls, shall be clearly identified and accessible only to skilled or instructed persons.

55-6.5 Electrical supply system

55-6.5.1 Electrical safety sources

NOTE See PART THREE for general requirements of permissible sources.

55-6.5.1.1 Safety sources for supplying safety equipment shall be selected according to the required response time and rated operating time. Where a separate power supply is used, the required operating time of any batteries may be reduced if the safety equipment requiring power is supplied from the generating set for the required operating time.

NOTE A battery charger in itself is not a safety source.

55-6.5.1.2 Electrical safety sources shall be installed as fixed equipment. Failure of the normal supply shall not adversely affect the performance of the safety sources.

55-6.5.1.3 Electrical safety sources shall be accessible only to skilled or instructed persons.

55-6.5.1.4 The location of every electrical safety source shall be properly and adequately ventilated so that any exhaust gases, smoke or fumes from the source are prevented from penetrating areas occupied by persons.

55-6.5.1.5 Separate independent feeders shall not serve as the normal and electrical safety sources unless the suppliers give written assurance that the two supplies are unlikely to fail concurrently.

55-6.5.1.6 An electrical safety source may be used for purposes other than safety services, if the availability for safety services is thereby not impaired. In addition to the requirements of 55-6.2, a fault occurring in a circuit used for purposes other than safety services shall not lead to the interruption of any circuit for safety services.

NOTE In an emergency, where safety services are needed, it may be necessary to off-load equipment not providing safety services.

55-6.5.1.7 The operational status of the safety source (whether normal or fault condition) shall be indicated at a central point that is constantly monitored at all required times. This does not apply to self-contained battery units.

55-6.5.1.8 A dual supply system with two independent feeders may be used. This applies, for example, in the case of:

- supply from a public distribution network and an independent power source,
- two independent public distribution networks (unlikely to fail concurrently).

The two separate feeders for a dual system shall meet the following requirement:

- a fault in the power supply system of one supply shall not cause faults in the power supply system of the other one.

If there is a fault in the normal source feed from one of the supplies the other supply shall at least ensure that the essential safety equipment is supplied.

55-6.5.1.9 Generating sets with reciprocating internal combustion engines, used as the prime mover, shall comply with ISO 8528-12.

NOTE These generally consist of a diesel engine as the prime mover and a synchronous machine as the generator. Other prime movers and generators may be used when they meet the requirements of ISO 8528-12 for fuel feed and cooling, operational performance, consistent voltage and frequency and adequate continuous short-circuiting power.

55-6.5.1.10 The safety source shall have sufficient capacity for the safety services.

55-6.5.1.11 Where the safety services of several buildings or locations are supplied from a single safety source, failure in the safety services of one building or location shall not endanger the normal operation of the safety source.

The following conditions shall be indicated at a central, continuously monitored point throughout the period required for operation:

a) supply failure at switchgear and controlgear to which safety services are connected;

b) operational status of all switching devices in the system if they are critical as regards the safety services;

c) first fault to earth.

55-6.6 Wiring systems

55-6.6.1 Circuits for electrical safety services shall be independent of the supply to other circuits.

NOTE 1 This means that an electrical fault or any intervention or modification in one system will not affect the correct functioning of the other. This may necessitate separation by fire-resistant materials or different routes or enclosures.

NOTE 2 The charging supply to self-contained battery units may be dependent on the supply to other circuits.

55-6.6.2 Circuits for safety services shall not pass through locations exposed to fire risk (BE2), unless they possess inherently high resistance against fire and physical damage or are suitably protected. The circuit shall not in any case pass through zones exposed to explosion risk (BE3).

55-6.6.3 The following wiring systems shall be provided for safety services required to operate in fire conditions:

a) mineral-insulated cable complying with SASO IEC 60702-1 and SASO IEC 60702-2;

b) fire-resistant cables complying with SASO 2010, SASO 2037 and SASO 752;

c) a wiring system maintaining the necessary fire and mechanical protection.

55-6.6.4 Wiring systems and cables for safety services, other than those mentioned in 55-6.6.3, shall be adequately and reliably separated from other cables, including cables of other safety services by distance or barriers.

NOTE For battery cables, special requirements may apply.

55-6.6.5 Supplies for safety services, with the exception of wiring for fire-brigade lifts, shall not be installed in lift shafts or other flue-like openings.

55-6.6.6 Safety circuits shall be installed and identified so as to avoid unintentional disconnection.

55-6.6.7 In rooms and escape routes with several emergency lighting luminaires, these shall be wired alternately from at least two separate circuits such that a level of illuminance is maintained along the escape route in the event of the loss of one circuit.

55-6.6.8 Wiring to battery chargers, including self-contained battery units, is not considered to be part of the safety circuit.

55-6.6.9 If the voltage of the safety power supply differs from that of the general power supply and transformers are required, they shall have separate windings.

55-6.7 Safety (Emergency) lighting circuits

55-6.7.1 Non-maintained emergency lighting luminaires shall be activated by failure of the supply to the normal lighting luminaires in the area in which they are located.

55-6.7.2 In the maintained mode, the normal source shall be monitored at the main distribution board. This does not apply to self-contained battery units.

NOTE: For definitions of Maintained & non-maintained modes, refer to SASO 2012.

55-6.7.3 The values for minimum illuminance are given by SASO 2012 "Emergency lighting systems in public buildings".

55-6.7.4 Luminaires shall comply with the requirements set out in SASO 1688.

55-6.7.5 No Electrical equipment and no lamps, other than those specified as required for emergency use shall be supplied by emergency lighting circuits.

55-6.7.6 Circuits that supply emergency lighting shall be installed to provide service from another source when the normal supply for lighting is interrupted. Such installations shall provide either maintained or non-maintained mode. Either or both modes shall be permitted to be part of the general lighting system of the protected occupancy if circuits supplying lights for emergency illumination are installed in accordance with these Electrical Requirements.

55-7 Socket-Outlets

55-7.1 Scope

This section specifies the rules and requirements for the installation of socket-outlets, and all the related accessories.

It covers fixed socket-outlets for a.c. only with or without earthing contact, with a rated voltage up to 400 V intended for residential, public buildings, industrial and similar purposes for indoor or outdoor.

55-7.2 Assessment of general characteristics

Socket-outlets and surface-type mounting boxes shall be so installed that, in normal use, their performance is reliable and without causing danger or to the user or to the surroundings within the purpose of these Electrical Requirements.

55-7.3 Power supply

The power supply for the electrical installation in residential and communal (Public) buildings is three-phase 220/127V, 60 Hz. For industrial buildings is three phase 380 /220 V, 60 Hz.

NOTE 220V supply is recommended for socket-outlets intended to be used for residential buildings and similar uses.

55-7.4 Protection for safety

55-7.4.1 Protection against electric shock

Socket-outlets for SELV and PELV systems shall comply with the requirements mentioned in statement 41-1.1.3.3 of Chapter 41.

55-7.4.1.1 Protection against direct contact

a) Socket-outlets shall be so installed that when they are mounted and wired as for normal use, live parts are not accessible, even after removal of parts, which can be removed without the use of a tool.

b) Parts which are accessible when the socket-outlet is wired and mounted as for normal use, shall be made of insulating material with the exception of small screws and the like, isolated from live parts, for fixing bases and covers of socket-outlets.

c) The covers of fixed socket-outlets and accessible parts of plugs may be made of metal if one of the following requirements is fulfilled:

- Metal cover plates are protected by supplementary insulation made by insulating linings or insulating barriers fixed to covers, in such a

way that they cannot be removed from covers without being permanently damaged, and that, if they are omitted, the accessories are rendered inoperable and there is no risk of accidental contact between live parts and metal covers, for example through their fixing screws, even if a conductor should come away from its terminal.

- Metal cover plates are automatically connected, through a low resistance connection, to the earth during fixing of the cover plate.

d) Socket-outlets shall be equipped with shutters.

55-7.4.1.2 Additional protection by residual protective devices

Where socket-outlets required to be protected by RCD according to 41-2.5, are supplied through circuit without RCD they shall be equipped with built-in type residual current device with rated operating residual current not exceeding 30 mA.

NOTE The use of high sensitivity residual protective devices provides additional protection against direct contacts in the event of the failure of other protective measures.

55-7.4.1.3 Protection against indirect contact

a) This protection can be achieved by:

- using socket-outlets intended to be used with class II appliance.
- using socket-outlets, each one is supplied by an isolating transformer.

b) Socket-outlet shall not be mounted at a distance less than 600 mm measured horizontally from any tap sink, basin in any kitchen, etc.

55-7.4.2 Protection against thermal effects

55-7.4.2.1 Protection against fire

a) Socket-outlets shall not be mounted at locations where they are liable to come into physical contact with fabrics or other flammable materials that may catch fire due to transmission of heat.

b) Socket-outlets shall not be installed above cooking appliances. Socket-outlet shall be located not less than 600 mm measured horizontally from a cooking appliance.

55-7.4.2.2 Protection against burns

Accessible parts of socket-outlets shall not attain a temperature likely to cause burns to persons, and shall comply with the appropriate limit stated in Table 42-1 of Chapter 42.

55-7.4.3 Protection against overcurrent

a) Protective devices shall be provided to break any overcurrent flowing in the circuit conductors of socket-outlets.

b) Every circuit shall have, at its origin, on the phase, a protection device against overcurrents.

c) Overcurrent protective devices (circuit breaker or fuse) shall be according to 43-2.1 of Chapter 43 and shall satisfy the requirements of 43-3 and 43-4.5.1.

55-7.5 Selection and erection

55-7.5.1 Common rules

55-7.5.1.1 Compliance with standards

a) Socket-outlets intended for use in residential premises shall comply with the following relevant Saudi Standards:

- SASO 2203 “Plugs and socket-outlets for household and similar general use", 220V.
- SASO 2204 “Plugs and socket-outlets for household and similar general use", 127V.

b) Socket-outlets intended for use in industrial premises shall comply with SASO 1693 and SASO IEC 60309-2.

55-7.5.1.2 Operational conditions

a) Nominal voltage

Nominal voltage ranges for socket-outlets installations are:

- Extra-low-voltage
  - Normally not exceeding 50 V a.c.
- Low-voltage
  - For residential and similar purposes: 220 V between phases or 127 V between any phase and neutral.
  - For industrial and similar purposes: 380 V between phases or 220 V between any phase and neutral.

b) Ratings

- Unless otherwise specified in these Electrical Requirements, ratings of socket-outlets for residential, commercial premises and other similar use shall be 127 V/15 A and/or 220 V/13 A.
- For industrial premises purposes, socket-outlets are preferred to have the ratings mentioned in SASO 1693.

55-7.5.1.3 External influences

a) Enclosures of socket-outlets shall provide protection against access to hazardous parts, harmful effects due to ingress of solid foreign objects and harmful effects due to ingress of water in accordance with the IP designation of the socket-outlets.

b) Surface-type socket-outlets having an IP code higher than IP20 shall be according to their IP classification when fitted with conduits or with sheathed cables.

c) Surface-type socket-outlets having degrees of protection IPX4 and IPX5 shall have provision for opening a drain hole.

d) Surface-type socket-outlets shall be so constructed that the conduit or sheath of the cable can enter at least 1 mm into the enclosure.

e) Socket-outlets installed in the floor shall have a degree of protection at least IP24 and IK08.

f) Socket-outlets to be located outside the buildings shall be protected against water splashing (IP24) and shall be (IP25) in locations likely to be sprayed with water jet.

55-7.5.2 Wiring systems

55-7.5.2.1 General

The wiring system shall comprise insulated conductors or cables with their supports and mechanical protection. The conductors and cables are laid in accordance with the installation method described in Table 52-2 of Chapter 52. The wiring system shall satisfy the following conditions:

a) The wiring for each circuit for socket-outlets shall carry two live conductors (phase and neutral or two phases) and a protective conductor for residential installations.

b) Each wiring shall be provided with a protective conductor, even if it is intended to supply class II appliances. This protective conductor shall be left in standby to be used if the class II socket-outlets are later replaced by class I socket-outlet.

c) All conductors shall have the same cross-sectional area.

d) A neutral conductor shall not be common to different circuits.

e) All circuits are individually protected against overcurrent.

f) All circuits are part from the same main circuit breaker.

55-7.5.2.2 Colours of the conductors

The colours of the conductors shall be according to 51-4.2 of Chapter 51.

55-7.5.2.3 Final mounted position of socket-outlets

a) Socket-outlets of rating 127 V/15 A, the earth contacts of each socket shall be effectively connected to the earth continuity conductor and the phase and neutral shall be connected to the correct sockets. When viewed from the front in its final mounted position, earth hole shall be at the bottom, the neutral hole shall be above to the left and the phase hole shall be above to the right.

b) Socket-outlets of rating 220V/13 A, the earth contact of each socket shall be effectively connected to the earth continuity conductor. When viewed from the front in its final mounted position, earth hole shall be at the top and the two phase holes shall be below.

55-7.5.2.4 Cross-sectional areas of conductors

a) Only copper conductors for socket-outlets circuits shall be used.

b) Unless otherwise specified, the maximum number of socket-outlets per circuit, and cross-sectional area of copper conductors are shown in Table 55-1.

Table 55-1 Maximum number of socket-outlets per circuit and the cross-sectional area of copper conductors

Function	Maximum number of socket-outlets per circuit	Cross-sectional area of copper conductors (mm^2)
Socket-outlets 220 V/13 A	8	2.5
Socket-outlets 127 V/15 A	8	4

55-7.5.2.5 Terminals and termination

Socket-outlets shall be provided with terminals, which should allow the proper connection of copper conductors.

55-7.5.3 Installation of fixed socket-outlets

55-7.5.3.1 General requirements

a) Socket-outlets shall be so installed as to permit easy connection of the conductors in the terminals; easy fixing of the base to a wall or in a mounting box; and correct positioning of the conductors.

b) Space between the underside of the base and the surface on which the base is mounted or between the sides of the base and the enclosure (cover or box) shall be adequate so that, after installation of the socket-outlet, the insulation of the conductors is not pressed against live parts of different polarity.

Surface type socket-outlets to be mounted on a mounting plate, may be provided with a wiring channel to comply with this requirement.

In addition, socket-outlets shall permit easy positioning and removal of the cover-plate, without displacing the conductors.

c) Cover-plates shall be held in place at two or more points by effective fixings.

d) Surface-type socket-outlets shall be so installed that, when they are fixed and wired as for normal use, there are no free openings in their enclosures other than the entry openings for the pins of the plug or other

openings for contacts, for example, side earthing contacts, or locking devices, etc.

e) Screws or other means for mounting the socket-outlet on a surface in a box or enclosure shall be easily accessible from the front. These means shall not serve any other fixing purpose.

f) Socket-outlets installed in masonry walls (stone, brick, concrete, etc.) shall be housed in an embedded box. The wiring shall be mechanically protected up to the point at which it enters the embedding box.

55-7.5.3.2 Special requirements

a) Socket-outlets shall not be an integral part of lamp holders.

b) If more than 8 socket-outlets are to be installed in the kitchen, a second circuit shall be used. In no circumstances will socket-outlets installed in the kitchen be permitted to be connected to circuits comprising socket-outlets in other rooms.

c) 220V/13 A switched socket-outlets are preferred to be used in the kitchen. They shall be connected to their individual circuit from the distribution board using 4 mm^2 copper conductors cable for all live and earth conductors.

d) In every dining room, sitting room, bedroom and similar rooms with general access, excluding kitchens, bathrooms, toilets and showers, socket-outlets shall be installed so that no point along the floor line of any wall is more than 2 m horizontally from a socket-outlet.

55-7.5.3.4 Mounting heights of socket-outlets

a) Except where otherwise specified, all socket-outlets shall be mounted 300 mm above the finished floor for indoor installation.
For Arabic majles, socket-outlets shall be mounted at a height to be agreed between the owner and the installer but not less than 700 mm.

b) Socket-outlets located outside the buildings shall be installed at a height of 1 meter above the earth.

c) Socket-outlets in the kitchen shall be mounted 300 mm above worktop (workbench) level as a minimum height.

55-7.5.5 Provision for earthing

Socket-outlets shall contain an earth contact except for the following cases where earthing shall not be provided:

a) Socket-outlets supplied by an isolating transformer (e.g. shaver socket-outlet).

b) Socket-outlets intended to be used with class II equipment.

c) Socket-outlets supplied by SELV or PELV.

55-8 Electric Appliances

55-8.1 Scope

This section specifies the requirements of the installation for electric appliances normally used in any occupancy, such as residential, commercial and industrial locations. It covers appliances that are fixed in place or cord-and plug-connected, in general and some in common use appliances, in particular, such as, water heaters, ceiling fans, washing machines, etc.

55-8.2 Compliance with standards

Each appliance covered by this section shall be complying with SASO 1062 and other relevant Saudi standards. In the absence of a Saudi standards dealing with a particular appliance, this appliance shall be complying with the relevant International standard.

Appliances for use in special locations shall comply with relevant Chapter of PART SEVEN.

55-8.3 Protection against electric shock

Appliances shall have no live parts normally exposed to contact other than those parts functioning as open-resistance heating elements, such as the heating element of a toaster, which are necessarily exposed.

55-8.4 Circuit overcurrent protection

Circuits shall be protected in accordance with 44-3. If a protective device rating is marked on an appliance, the circuit over current device rating shall not exceed the protective device rating marked on the appliance.

55-8.5 Wiring system

This sub-section specifies sizes of circuits capable of carrying appliances current without overheating under the conditions specified. This sub-section shall not apply to conductors that form an integral part of appliance.

55-8.5.1 Individual circuits

The individual circuits shall be complying with:

- The rating of an individual circuit shall not be less than the rated current of the appliance or the rating of an appliance having combined loads.
- Any appliance having a rated current of more than 15A in case of 127V or more than 13A in case of 220V shall be supplied from an Individual circuit.
- The operation of 220V (phase-to-phase) appliance shall be controlled through a double pole switch of a suitable current rating.
- Any appliance having a rated current of more than 15A in case of 127V or more than 13A in case of 220V permitted to be cord-and-plug connected with a flexible cord shall be supplied from a special socket outlet in accordance with SASO 1693, rated for the rated current of the appliance.
- If an appliance is provided with installation instructions from the manufacturer, the circuit size is not permitted to be less than the minimum size stated in the installation instructions.

55-8.5.2 Circuits supplying two or more loads

The rating of a circuit supplying two or more fixed appliance loads shall not be less than total rated appliances current.

55-8.6 Flexible cords and supply connection

55-8.6.1 Flexible Cords

Flexible cord shall be permitted in two cases:

a) for the connection of appliances to facilitate their frequent interchange or to prevent the transmission of noise or vibration or;

b) to facilitate the removal or disconnection of appliances that are fixed in place, where the fixing means and mechanical connections are specifically designed to permit ready removal for maintenance or repair and the appliance is intended or identified for flexible cord connection.

All cord- and plug-connected appliances that are producing heat shall be provided with appropriate heat resistance cord.

55-8.6.2 Supply connection

Appliances intended to be permanently connected to fixed wiring shall allow the connection of the supply conductors after the appliance has been fixed to its support.

Note If a fixed appliance is constructed so that parts can be removed to facilitate easy installation, the requirement is considered to be met if it is possible to connect the fixed wiring without difficulty after a part of the appliance has been fixed to its support. In this case, removable parts are to be constructed for ease of reassembly without risk of incorrect assembly or damage to the wiring or terminals.

55-8.6.3 Supply Disconnection

For stationary appliances, means shall be provided to ensure all-pole disconnection from the supply mains. Such means shall be one of the following:

- a supply cord fitted with a plug;
- a switch complying with SASO 1062;
- a statement in the instructions that a disconnection incorporated in the fixed wiring is to be provided;
- an appliance inlet.

In single-phase circuits, single-pole switches, and single-pole protective devices that disconnect permanently connected class I appliances from the supply mains, shall be connected to the phase conductor.

55-8.7 Earthing

Each appliance required to be earthed, shall have exposed non-current-carrying metal parts earthed in the manner specified in Chapter 54.

55-8.8 Installation requirements for some of the electrical appliances in common use

55-8.8.1 Washing machines

55-8.8.1.1 Washing machines shall be in accordance with SASO 1062, SASO 2025, SASO 140 and SASO 141.

55-8.8.1.2 Washing machines shall have a degree of protection not less than IPX4.

55-8.8.1.3 Circuits supplying washing machines shall be protected by RCD in accordance with 41-2.5.

55-8.8.1.4 Accessible metal parts of class I washing machines, which may become live in the event of insulation fault, water tub and the other metal parts, which touch the water, shall be permanently and liable connected to an earthing terminal within the washing machine

NOTE Transportable machines fitted with castor or wheels should remain stationary while in operation.

55-8.8.2 Electric Water heaters

55-8.8.2.1 Water heaters shall be in accordance with SASO 531, SASO 532, SASO 1698, SASO 1603 and SASO 1062.

55-8.8.2.2 Storage closed-type water heaters for outdoor installation shall have a degree of protection not less than IPX4. Other storage closed-type water heaters shall have a degree of protection not less than IPX1.

55-8.8.2.3 Instantaneous water heaters shall have degree of protection not less than IPX1.

55-8.8.2.4 Temperature-limiting device

Each storage or instantaneous-type water heater shall be equipped with a temperature-limiting means (non-self resetting thermal cut-out) in addition to its control thermostat to disconnect all unearthed conductors, and such means shall be:

- Installed to sense maximum water temperature, and
- Either a trip-free, manually reset type or a type having a replacement element.

Water heaters shall be marked to require the installation of a temperature and pressure relief valve.

55-8.8.2.5 Water heaters shall be supplied from a separate circuit and through double pole switch.

55-8.8.2.6 Water heaters shall have exposed non-current-carrying metal parts earthed in the manner specified in Chapter 54.

55-8.8.2.7 Circuits supplying instantaneous-type water heaters shall be protected by RCD in accordance with 41-2.5.

55-8.8.3 Ceiling Fans

55-8.8.3.1 Ceiling fans shall be in accordance with SASO 1062, SASO 112, SASO 113 and SASO 2031.

55-8.8.3.2 For fans intended to be mounted at high level, fans shall be installed so that the blades are more than 2.3 m above the floor.

55-8.8.3.3 Fans having provision for attaching a luminaire shall incorporate appropriate terminals and wiring.

55-8.8.3.4 Ceiling-Suspended Fans with or without accessories, shall be supported in an approved manner, and shall not be permitted to be supported by outlet boxes.

55-8.8.4 Tumble dryers

55-8.8.4.1 Tumble dryers shall be in accordance with SASO 1062 and SASO 1977.

55-8.8.4.2 Tumble dryers have a degree of protection not less than IPX4.

55-8.8.4.3 Tumble dryers shall be supplied from a separated circuit and through a switch of all-pole disconnection.

55-8.8.5 Room air conditioners and desert coolers

55-8.8.5.1 Room air conditioners shall be in accordance with SASO 386 and SASO 1062.

55-8.8.5.2 Desert coolers shall be in accordance with SASO 35 and SASO 1062.

55-8.8.5.3 Room air conditioners and desert coolers shall be earthed in accordance with Chapter 54.

55-8.8.5.4 Desert coolers shall be protected by RCD in accordance with 41-2.5.

55-8.8.5.5 Room air conditioners and Desert coolers shall be supplied from a separate circuit and through a double pole switch.

55-8.8.5.6 Disconnecting means shall be located within sight from and readily accessible from the air-conditioning or desert coolers.

The disconnecting means shall be permitted to be installed on or within the air-conditioning or desert coolers.

Disconnecting means shall be located so that spillage of liquid will not result in a risk of fire or electric shock.

55-8.9 Marking

Each appliance shall be provided with a nameplate, which shall be legibly and indelibly marked with the information required by relevant Saudi Standard, in Arabic or English.

55-9 Luminaires and Lighting Installations

55-9.1 Scope

This section applies to the selection and erection of luminaires and lighting installations intended to be part of the fixed installation.

Requirements for specific types of lighting installations for special locations are covered in Chapters 713, 714 and 715.

The requirements of this section includes lighting of some special application.

NOTE Safety requirements for luminaires are covered by SASO 1318.

55-9.2 Requirements for Luminaire Installations

Luminaires shall be selected and installed in accordance with the manufacturer's instructions and the relevant SASO 1318.

55-9.2.1 Coves for lighting shall have adequate space which is necessary for easy access for relamping luminaires or replacing lamp holders, ballasts, and so on; adequate space also improves ventilation.

55-9.2.2 Canopies and outlet boxes taken together shall provide adequate space so that luminaire conductors and their connecting devices can be properly installed.

55-9.2.3 Lighting Track Systems

55-9.2.3.1 Lighting Track system is a manufactured assembly designed to support and energize luminaires that are capable of being readily repositioned on the track. Its length may be altered by the addition or subtraction of sections of track.

55-9.2.3.2 Lighting track shall be permanently installed and permanently connected to a circuit. Only lighting track fittings shall be installed on lighting track.

Lighting track fittings shall not be equipped with general-purpose socket-outlets.

55-9.2.3.3 For the lighting track branch-circuit load, the maximum load on the track cannot exceed the rating of the circuit supplying the track. Also, the track must be supplied by a circuit having a rating not exceeding the rating of the track. The track length does not enter into the branch-circuit calculation.

55-9.2.3.4 Lighting track shall not be installed in the following locations:

- Where likely to be subjected to physical damage;
- In wet or damp locations;
- Where subject to corrosive vapours;
- In storage battery rooms;
- In hazardous (classified) locations;
- Where concealed;
- Where extended through walls or partitions;
- Less than 1.5 m above the finished floor except where protected from physical damage or track operating at SELV.

55-9.2.3.5 Fittings identified for use on lighting track shall be designed specifically for the track on which they are to be installed. They shall be securely fastened to the track, shall maintain polarization and earthing, and shall be designed to be suspended directly from the track. The track conductors shall be of 4 mm^2 minimum cross-section copper conductors.

55-9.2.3.6 Heavy-duty lighting track is a lighting track identified for use exceeding 20 A. Each fitting attached to a heavy-duty lighting track shall have individual overcurrent protection.

55-9.2.4 Mechanical Strength.

55-9.2.4.1 Luminaires and lampholders shall be securely supported. A luminaire that weighs more than 3 kg or exceeds 400 mm in any dimension shall not be supported by the screw shell of a lampholder.

55-9.2.4.2 Tubing used for arms and stems where provided with cut threads shall not be less than 1.0 mm in thickness and where provided with rolled (pressed) threads shall not be less than 0.64 mm in thickness. Arms and other parts shall be fastened to prevent turning.

55-9.2.4.3 Metal canopies supporting lampholders, shades, and so forth exceeding 4 kg shall not be less than 0.5 mm in thickness. Other canopies shall not be less than 0.4 mm if made of steel and not less than 0.5 mm if of other metals.

55-9.3 Protection against electric shock

Luminaires and lighting equipment shall be earthed according to the following:

55-9.3.1 Exposed metal parts shall be earthed or insulated from earth and other conducting surfaces or shall be inaccessible to unqualified personnel.

55-9.3.2 Luminaires directly wired or attached to outlets supplied by a wiring method that does not provide a ready means for earthing shall be made of insulating material and shall have no exposed conductive parts.

55-9.3.3 Replacement luminaires shall be permitted to connect an equipment earthing conductor from the outlet, and then the luminaire shall be earthed.

55-9.3.4 Exposed live parts within porcelain luminaires shall be suitably recessed and located so as to make it improbable that wires come in contact with them. There shall be a spacing of at least 13 mm between live parts and the mounting plane of the luminaire.

55-9.3.5 Luminaires with exposed metal parts shall be provided with a means for connecting an equipment earthing conductor for such luminaires.

55-9.3.6 Luminaires and equipment shall be considered earthed where mechanically connected to an equipment earthing conductor.

55-9.3.7 Parts that must be removed for lamp replacement shall be hinged or held captive. Lamps or lampholders shall be designed so that there are no exposed live parts when lamps are being inserted or removed.

55-9.3.8 Equipment having an open-circuit voltage exceeding 300 volts shall not be installed in residential occupancies unless such equipment is designed so that there will be no exposed live parts when lamps are being inserted, are in place, or are being removed.

Luminaires intended for use in non-residential occupancies are so marked. This marking usually indicates that the luminaire has maintenance features that are considered beyond the capabilities of the ordinary homeowner or the luminaire involves voltages in excess of those permitted by these Electrical Requirements for residential occupancies.

55-9.3.9 Special Provisions for Electric-Discharge Lighting Systems of more than 1000V (lamp voltage).

55-9.3.9.1 Electric-discharge lighting systems with an open-circuit voltage exceeding 1000 volts shall be listed and installed in conformance with that listing.

55-9.3.9.2 Equipment that has an open-circuit voltage exceeding 1000 volts shall not be installed in or on residential occupancies.

55-9.3.9.3 The terminal of an electric-discharge lamp shall be considered as a live part in addition to complying with the general requirements for luminaires.

55-9.4 Protection against thermal effects

55-9.4.1 For the selection of luminaires with regard to their thermal effect on the surroundings, the following features shall be taken into account:

a) the maximum permissible power dissipated by the lamps;

b) fire resistance of adjacent material

- at the point of installation,
- in the thermally affected areas;

c) minimum distance to combustible materials, including those in the path of a spotlight beam.

55-9.4.2 Depending on the fire resistance of the material at the point of installation and in thermally affected areas, the manufacturer's installation instructions shall be followed. Marked luminaires shall be selected and installed according to the marking as specified in SASO 1318.

NOTE For special installations or locations, additional requirements may apply, e.g. those in Chapter 42 in the case of locations with fire risk or those in 713 in the case of furniture.

55-9.4.3 Thermal Effects on combustible materials

55-9.4.3.1 Luminaires near combustible materials.

Luminaires shall be constructed, installed, or equipped with shades or guards so that combustible material is not subjected to temperatures in excess of 90°C.

55-9.4.3.2 Luminaires over combustible materials.

Lampholders installed over highly combustible material shall be of the unswitched type. Unless an individual switch is provided for each luminaire, luminaires should be with relevant marking.

55-9.4.4 Luminaires installed in recessed cavities in walls or ceilings shall comply with the following statements:

55-9.4.4.1 Luminaires shall be installed so that adjacent combustible material will not be subjected to temperatures in excess of 90°C.

55-9.4.4.2 Where a luminaire is recessed in fire-resistant material in a building of fire-resistant construction, a temperature higher than 90°C but not higher than 150°C shall be considered acceptable if the luminaire is plainly marked that it is suitable for that service.

55-9.4.4.3 Recessed incandescent luminaires shall have a marking stating the maximum lamp power used and should be visible during relamping.

Example: a recessed luminaire identified for use and installed in poured concrete.

55-9.4.4.4 A recessed luminaire that is not identified for contact with insulation shall have all recessed parts spaced not less than 13 mm from combustible materials. The points of support and the trim finishing off the opening in the ceiling or wall surface shall be permitted to be in contact with combustible materials.

55-9.4.4.5 A recessed luminaire that is identified for contact with insulation, shall be permitted to be in contact with combustible materials at recessed parts, points of support, and portions passing through or finishing off the opening in the building structure.

55-9.4.4.6 Thermal insulation shall not be installed above a recessed luminaire or within 75 mm of the recessed luminaire’s enclosure, wiring compartment, or ballast unless it is identified for contact with insulation.

55-9.4.5 All luminaires should be thermally tested and complying to SASO 1318 and other particular requirements of luminaires.

55-9.5 Wiring systems

55-9.5.1 Where a pendant luminaire is installed, the fixing accessories shall be capable of carrying five times the mass of the connected luminaire, but not less than 25 kg. The cable or cord between the suspension device and the luminaire shall be installed so that excessive tensile and torsional stresses in the conductors and terminations are avoided.

NOTE See also 52-2.8 of Chapter 52.

55-9.5.2 Where cables and/or insulated conductors are drawn through the luminaires by the installer (through-wiring), suitable cables and/or insulated

conductors, as specified in 55-9.6.3, shall be selected and only luminaires suitable for through-wiring shall be used.

55-9.5.3 Cables shall be selected in accordance with the temperature marking on the luminaire, if any, as follows:

- for luminaires complying with SASO 1318 but with no temperature marking, heat resistant cables are not required;
- for luminaires complying with SASO 1318 with temperature marking, cables suitable for the marked temperature shall be used;
- for luminaires not marked as complying with SASO 1318, the manufacturer's instructions shall be followed;
- in the absence of information, heat-resistant cables and/or insulated conductors in accordance with relevant Saudi Standards or those of an equivalent type shall be used.

NOTE Local reinforcement or substitution of insulating material may be used (see 52-2.2 of Chapter 52).

55-9.5.4 Groups of luminaires, which are divided between the three phase conductors of a three-phase system with only one common neutral conductor, shall be treated as three-phase current-using equipment.

NOTE See also 53-6.2.1.1 of Chapter 53.

55-9.5.5 Luminaire Wiring

55-9.5.5.1 Wiring on or within fixtures shall be neatly arranged and shall not be exposed to physical damage. Excess wiring shall be avoided. Conductors shall be arranged so that they are not subjected to temperatures above those for which they are rated.

55-9.5.5.2 Luminaires shall be wired so that the screw shells of lampholders are connected to the same luminaire or circuit conductor or terminal. The earthed conductor, where connected to a screw-shell lampholder, shall be connected to the screw shell (polarization of luminaires).

55-9.5.5.3 Luminaires shall not be used as a raceway for circuit conductors unless listed and marked for use as a raceway.

55-9.6 Independent lamp controlgear, e.g. ballasts

Only independent lamp controlgear marked as suitable for independent use, according to the relevant standard, shall be used outside luminaires.

NOTE The generally recognized symbol is:  independent ballast 5138 of relevant Saudi Standards.

55-9.7 Compensation capacitors

Compensation capacitors having a total capacitance exceeding 0.5 μF shall only be used in conjunction with discharge resistors.

NOTE 1 See also 53-6.2.1.4 of Chapter 53.

NOTE 2 Capacitors and their marking should be in accordance with relevant Saudi Standards.

55-9.8 Protection against electric shock for display stands for luminaires

Protection against electric shock shall be provided by either:

- SELV supply, or
- Automatic disconnection of a supply using a residual current operated protective device having a rated residual operating current not exceeding 30 mA.

55-9.9 Stroboscopic effect

In the case of lighting for premises where machines with moving parts are in operation, consideration shall be given to stroboscopic effects, which can give a misleading impression of moving parts being stationary. Such effects may be avoided by selecting suitable lamp controlgear (high frequency electronic type).

55-9.10 Luminaires in Specific Locations

55-9.10.1 Luminaires installed in wet locations shall be installed so that water cannot enter or accumulate in wiring compartments, lampholders, or other electrical parts. All luminaires installed in wet locations shall have at least (IPX4) unless otherwise specified in other parts of these Electrical Requirements.

55-9.10.2 Luminaires installed in corrosive locations shall be of a type suitable for such locations.

55-9.10.3 Luminaires shall be permitted to be installed in commercial cooking hoods where all of the following conditions are met:

- The luminaire shall be identified for use within commercial cooking hoods and installed so that the temperature limits of the materials used are not exceeded.
- The luminaire shall be constructed so that all exhaust vapours, grease, oil, or cooking vapours are excluded from the lamp and wiring compartment. Diffusers shall be resistant to thermal shock.
- Parts of the luminaire exposed within the hood shall be corrosion resistant or protected against corrosion, and the surface shall be smooth so as not to collect deposits and to facilitate cleaning.
- Wiring methods and materials supplying the luminaire(s) shall not be exposed within the cooking hood.

55-9.11 Luminaires for hazardous locations

55-9.11.1 In Zone 0 & 1 locations, luminaires shall comply with the following:

- Each luminaire shall be identified as a complete assembly for the Zone 0, location and shall be clearly marked to indicate the maximum wattage of lamps for which it is identified. Luminaires intended for portable use shall be specifically listed as a complete assembly for that use.
- Each luminaire shall be protected against physical damage by a suitable guard or by location.
- Pendant luminaires shall be suspended by and supplied through threaded rigid metal conduit stems or threaded steel intermediate conduit stems, and threaded joints shall be provided with set-screws or other effective means to prevent loosening. For stems longer than 300 mm, permanent and effective bracing against lateral displacement shall be provided at a level not more than 300 mm above the lower end of the stem, or flexibility in the form of a fitting or flexible connector identified for this location shall be provided not more than 300 mm from the point of attachment to the supporting box or fitting.
- Boxes, box assemblies, or fittings used for the support of luminaires shall be identified for classified locations.

55-9.11.2 In Zone 2 locations, luminaires shall comply with the following:

- Luminaires for fixed lighting shall be protected from physical damage by suitable guards or by location. Where there is danger that falling sparks or hot metal from lamps or fixtures might ignite localized concentrations of flammable vapors or gases, suitable enclosures or other effective

protective means shall be provided. Where lamps are of a size or type that may, under normal operating conditions, reach surface temperatures exceeding 80 percent of the ignition temperature in degrees Celsius of the gas or vapor involved, fixtures shall comply to Zone 1 and shall be of a type that has been tested in order to determine the marked operating temperature or temperature class (T Code).

- Pendant luminaires shall be suspended by threaded rigid metal conduit stems, threaded steel intermediate metal conduit stems, or other approved means. For rigid stems longer than 300 mm, permanent and effective bracing against lateral displacement shall be provided at a level not more than 300 mm above the lower end of the stem, or flexibility in the form of an identified fitting or flexible connector shall be provided not more than 300 mm from the point of attachment to the supporting box or fitting.
- Switches that are a part of an assembled fixture or of an individual lamp holder shall comply with Zone 2.
- Starting and control equipment for electric-discharge lamps shall comply with Zone 2.

55-9.11.3 In Zone 0, 1 & 2 locations, luminaires shall comply with the following:

55-9.11.3.1 In Zone 20 & 21 locations, luminaires for fixed and portable lighting shall comply with the following:

- Each luminaire shall be identified for Class II locations and shall be clearly marked to indicate the maximum wattage of the lamp for which it is designed. In locations where dust from magnesium, aluminium, aluminium bronze powders, or other metals of similarly hazardous characteristics may be present, luminaires for fixed or portable lighting and all auxiliary equipment shall be identified for the specific location.
- Each luminaire shall be protected against physical damage by a suitable guard or by location.
- Pendant luminaires shall be suspended by threaded rigid metal conduit stems, threaded steel intermediate metal conduit stems, by chains with approved fittings, or by other approved means. For rigid stems longer than 300 mm, permanent and effective bracing against lateral displacement shall be provided at a level not more than 300 mm above the lower end of the stem, or flexibility in the form of a fitting or a flexible connector listed for the location shall be provided not more than 300 mm from the point of attachment to the supporting box or fitting. Threaded joints shall be provided with set-screws or other effective means to prevent loosening. Where wiring between an outlet box or fitting and a pendant luminaire is not enclosed in conduit, flexible cord listed for hard usage shall be used, and suitable seals shall be provided where the cord enters the luminaire and the outlet box or fitting. Flexible cord shall not serve as the supporting means for a fixture.
- Boxes, box assemblies, or fittings used for the support of luminaires shall be identified for Class II locations.

Other than the requirement that the fixture be marked to indicate maximum lamp wattage, the only requirement for fixtures in Zone 2 locations is that lamps be enclosed in suitable globes to minimize dust deposits on the lamps and prevent the escape of sparks or burning material. Metal guards must be provided, unless globe breakage is unlikely.

Flexible cord of the hard-usage type is permitted with approved sealed connections for the wiring of chain-suspended or hook-and-eye-suspended

fixtures. Flexible cords are not intended to be used as cord pendants or drop cords.

55-9.11.3.2 In Zone 22 locations, luminaires shall comply with the following:

- Luminaires for fixed lighting, where not of a type identified for Class II locations, shall provide enclosures for lamps and lampholders that shall be designed to minimize the deposit of dust on lamps and to prevent the escape of sparks, burning material, or hot metal. Each fixture shall be clearly marked to indicate the maximum wattage of the lamp that shall be permitted without exceeding an exposed surface temperature according to temperature class under normal conditions of use.
- Luminaires for fixed lighting shall be protected from physical damage by suitable guards or by location.
- Pendant luminaires shall be suspended by threaded rigid metal conduit stems, threaded steel intermediate metal conduit stems, by chains with approved fittings, or by other approved means. For rigid stems longer than 300 mm, permanent and effective bracing against lateral displacement shall be provided at a level not more than 300 mm above the lower end of the stem, or flexibility in the form of an identified fitting or a flexible connector shall be provided not more than 300 mm from the point of attachment to the supporting box or fitting. Where wiring between an outlet box or fitting and a pendant luminaire is not enclosed in conduit, flexible cord listed for hard usage shall be used. Flexible cord shall not serve as the supporting means for a fixture.

HID lamp controlgear shall comply with group II requirements.

Illustration of IEC hazardous zones (refer to SASO IEC 60079 and SASO IEC 61241):

Zone 0: Areas where flammable gases are permanently available.

Zone 1: Areas where flammable gases are temporarily available but for long periods.

Zone 2: Areas where flammable gases are temporarily available but for short periods.

Zone 20: Areas where flammable dusts and flyings are permanently available.

Zone 21: Areas where flammable dusts and flyings are temporarily available but for long periods.

Zone 22: Areas where flammable dusts and flyings are temporarily available but for short periods.

PART SIX

VERIFICATION

CHAPTER 61
INITIAL AND PERIODIC VERIFICATION

61-0.1 Scope

This Chapter lays down requirements for the verification, by inspection and testing, of the compliance of the installation with the relevant requirements of other parts of these Electrical Requirements. Criteria for testing are given and tests are described.

This Chapter is concerned only with new installations; it is not concerned with the inspection and testing of existing installations. However, the criteria for inspection and the tests described may be applied, if thought appropriate, to existing installations.

61-0.2 General

61-0.2.1 Every installation shall, during erection and/or on completion before being put into service by the user, be visually inspected and tested by an accredited inspection body to verify, as far as practicable, that the requirements of this chapter have been met.

61-0.2.2 The information required by 51-4.5 of Chapter 51 shall be made available to the persons carrying out the verification.

61-0.2.3 Precautions shall be taken to avoid danger to persons and to avoid damage to property and installed equipment during inspection and testing.

61-0.2.4 Where the installation is an extension or alteration of an existing installation, it shall be verified according to this Chapter that the extension or alteration complies with these Electrical Requirements and does not impair the safety of the existing installation.

61-0.2.5 On completion of the inspection and testing done, a certificate shall be made, and submitted to the electricity authority for power supply release.

61-0.2.6 Verification shall be made by a skilled and certified/accredited person/body, competent in verification. On completion of the verification, a report shall be prepared.

NOTE 1 Information on periodic verification and Example of the test report format are given in the Annex G.61.

NOTE 2 For verification of special location and installation refer to the relevant Chapters of PART SEVEN.

NOTE 3 For verification of Lightning Protection Systems LPS see Annex F.61.

61-1 Initial Verification

61-1.1 Visual inspection

61-1.1.1 Visual inspection shall precede testing and normally be done with the whole installation or particularly that part of the installation under inspection totally disconnected.

61-1.1.2 The visual inspection shall be made to confirm that permanently wired electrical equipment is:

- in compliance with the safety requirements of the relevant equipment standards;

  NOTE This may be ascertained by examination of marking or certification furnished by the installer or by the manufacturer.
- correctly selected and erected according to these Electrical Requirements;
- not visibly damaged, so as to impair safety.

61-1.1.3 Visual inspection shall include at least the checking of the following, where relevant:

- Method of protection against electric shock, including measurement of distances, concerning, for example, protection by barriers or enclosures, by obstacles or by placing out of reach (see 41-0.3, 41-2.2, 41-2.3, 41-2.4 and 41-3.3 of Chapter 41);

  NOTE The requirement stated in 41-3.3 "Protection by non-conducting location" is verifiable only where the installation includes only permanently wired equipment.
- Presence of fire barriers and other precautions against propagation of fire and protection against thermal effects (see Chapters 42, 43 and 52-7 of Chapter 52);
- Selection of conductors for current-carrying capacity and voltage drop (see 52-3 of Chapter 52);
- Choice and setting of protective and monitoring devices (see Chapter 53);
- Presence of suitable isolating and switching devices correctly located (see Chapter 53);
- Selection of equipment and protective measures appropriate to external influences (see 51-2.2 of Chapter 51, 42-2 of Chapter 42 and 52-2 of Chapter 52);
- Identification of conductors (see 51-4.2 of Chapter 51);
- Presence of diagrams, warning notices or other similar information (see 51-4.5 of Chapter 51);
- Identification of circuits, fuses, switches, terminals, etc. (see 51-4 of chapter 51);
- Adequacy of connections of conductors (see 52-6 of Chapter 52);
- Accessibility for convenience of operation, identification and maintenance;
- Inspection of the emergency lighting as 55-6.7.

61-1.2 Testing

61-1.2.1 General

The following tests shall be carried out where relevant and should preferably be made in the following sequence:

- Continuity of the protective conductors and of the main and supplementary equipotential bonding (see 61-1.2.2);
- Insulation resistance of the electrical installation (see 61-1.2.3);
- Protection by separation of circuits (see 61-1.2.4);
- Floor and wall resistance (see 61-1.2.5);
- Automatic disconnection of supply (see 61-1.2.6);
- Polarity test (see 61-1.2.7);
- Electric strength test (see 61-1.2.8);
- Functional tests (see 61-1.2.9).

In the event of any test indicating failure to comply, that test and any preceding test, the results of which may have been influenced by the fault indicated, shall be repeated after the fault has been rectified.

The test methods described in this Chapter are given as reference methods; other methods are not precluded provided they shall give no less valid results.

NOTE Information on the requirements of measuring and monitoring equipment is given in the series of Saudi Standards.

61-1.2.2 Continuity of protective conductors, including the main and supplementary equipotential bonding

A continuity test shall be made. It is recommended that the test be carried out with a supply having a no-load voltage of 4 V to 24 V, d.c. or a.c., and with a minimum current of 0.2 A.

61-1.2.3 Insulation resistance of the electrical installation

The insulation resistance shall be measured:

a) Between live conductors taken in turn two by two;

NOTE In practice this measurement can only be carried out during erection of the installation before the connection of the appliances.

b) Between each live conductor and earth.

NOTE 1 In TN-C systems, the PEN conductor is considered as part of the earth.

NOTE 2 During this measurement, phase and neutral conductors may be connected together.

The insulation resistance, measured with the test voltage values indicated in Table 61-1 is satisfactory if each circuit, with the appliances disconnected, has an insulation resistance not less than the appropriate value given in Table 61-1.

Measurements shall be carried out with direct current. The testing apparatus shall be capable of supplying the test voltage specified in Table 61-1 when loaded with 1 mA.

Table 61-1 Minimum value of insulation resistance

Nominal circuit voltage V a.c.	**Test voltage** V d.c.	**Insulation resistance** MΩ
SELV and functional extra-low-voltage (FELV), when the circuit is supplied from a safety transformer (41-1.1.2.1) and also fulfils the requirements of 41-1.1.3.3	250	≥ 0.25
Up to and including 500 V a.c., with the exception of the above cases	500	≥ 0.5
Above 500 V a.c.	1 000	≥ 1.0

When the circuit includes electronic devices, only the measurement between phases and neutral, connected together, to earth shall be made.

NOTE This precaution is necessary because carrying out the test without a connection between live conductors could cause damage to electronic devices.

61-1.2.4 Protection by separation of circuits

The separation of the live parts from those of other circuits and from earth, according to 41-1.1 and 41-3.5 shall be verified by a measurement of the insulation resistance. The resistance values obtained shall be in accordance with Table 61-1, with the appliances, as far as possible, connected.

61-1.2.5 Floor and wall resistance

When it is necessary to comply with the requirements of 41-3.3, at least three measurements shall be made in the same location, one of these measurements being approximately 1 m from any accessible extraneous-

conductive-part in the location. The other two measurements shall be made at greater distances.

The above series of measurements shall be repeated for each relevant surface of the location.

Annex A.61 offers a method for measuring the insulating resistance of floors and walls.

61-1.2.6 Verification of conditions for protection by automatic disconnection of the supply

61-1.2.6.1 General

The verification of the efficacy of the measures for protection against indirect contact by automatic disconnection of supply is affected as follows:

a) For TN systems

Compliance with the rules of 41-3.1.3.3 of Chapter 41 shall be verified as follows:

1) Measurement of the fault loop impedance (see 61-1.2.6.3);

NOTE 1 Compliance may be verified by measurement of the resistance of protective conductors under the conditions described in the Annex E.61.

NOTE 2 The above measurements are not necessary where the calculations of the fault loop impedance or of the resistance of the protective conductors are available and when the arrangement of the installation permits the verification of the length and cross-sectional area of the conductors, in which case the verification of the continuity of the protective conductors (see 61-1.2.2) is sufficient.

2) Verification of the characteristics of the associated protective device (i.e. by visual inspection of the nominal current setting for circuit-breakers and the current rating for fuses and also by test for RCDs).

NOTE 3 Examples of methods for testing RCDs are shown in annex B.61.

In addition, the effective earthing resistance R_B shall be designed where necessary according to 41-3.1.3.7 of Chapter 41.

b) For TT systems

Compliance with the rules of 41-3.1.4.2 of Chapter 41 shall be verified by:

1) measurement of the resistance of the earth electrode for exposed-conductive-parts of the installation (see 61-1.2.6.2);

2) verification of the characteristics of the associated protective device. This verification shall be made:

- for RCDs by visual inspection and by test;

  NOTE Examples of methods for testing RCDs are shown in annex B.61.
- for overcurrent protective devices by visual inspection (i.e. current setting for circuit-breakers, current rating for fuses);
- for the protective conductors by inspection of their continuity (see 61-1.2.1).

c) For IT systems

Calculation or measurement of the first fault current.

NOTE 1 This measurement is not necessary if all exposed-conductive-parts of the installation are connected to the power system earth (see 31-2.2.3 of Chapter 31) in the case where the system is connected to earth through an impedance (see 41-3.1.5.1 of Chapter 41).

NOTE 2 The measurement is made only if the calculation is not possible, because all the parameters are not known. Precautions are to be taken while making this measurement in order to avoid the danger due to a double fault.

Where conditions which are similar to conditions of TT systems occur in the event of a second fault (see 41-3.1.5.5a of Chapter 41), verification is made according to point b) of this statement.

Where conditions similar to conditions of TN systems occur (see 41-3.1.5.5b of Chapter 41), verification is made according to point a) of this statement.

NOTE 3 During the measurement of the fault loop impedance; it is necessary to establish a connection of negligible impedance between the neutral point of the system and the protective conductor at the origin of the installation.

61-1.2.6.2 Measurement of the resistance of the earth electrode

Measurement of the resistance of an earth electrode, where prescribed (see 41-3.1.4.2 for TT systems and 41-3.1.3.3 for TN systems and 41-3.1.5.3 for IT systems), is made by an appropriate method.

NOTE 1 Annex C.61 gives, as an example, a description of a method of measurement using two auxiliary earth electrodes and the conditions to be fulfilled.

NOTE 2 Where, in a TT system, the location of the installation (e.g. in towns) is such that it is not possible in practice to provide the two auxiliary earth electrodes, measurement of the fault loop impedance (or resistance) will give an excess value.

NOTE 3 Where, for protection against lightning as per Chapter 802, the earth resistance test and its individual earth electrodes should be tested with adequate disconnecting means have been provided. Annex F.61 gives more information about the LPS verification.

61-1.2.6.3 Measurement of fault loop impedance

Measurement of the fault loop impedance shall be effected at the same frequency as the nominal frequency of the circuit.

NOTE 1 Annex D.61 provides examples of methods for measuring fault loop impedance.

The measured fault loop impedance shall comply with 41-3.1.3.3 for TN systems and with 41-3.1.5.6 for IT systems.

NOTE 2 When the fault loop impedance value might be influenced by significant fault currents, results of measurements made with such current in the factory or laboratory may be taken into account. This particularly applies to factory-built assemblies, including busbar trunking systems, metallic conduits and cables with metallic enclosures.

Where the requirements of this statement are not satisfied or in case of doubt and where supplementary equipotential bonding according to 41-3.1.6 is applied, the effectiveness of that bonding shall be checked by the method of 41-3.1.6.2.

61-1.2.7 Polarity test

Where the rules forbid the installation of single pole switching devices in the neutral conductor, a test of polarity shall be made to verify that all such devices are connected in the phase only.

61-1.2.8 Electric strength test

61-1.2.8.1 General

A test shall be applied on equipment built or modified on site, as per the relevant standard of the equipment.

61-1.2.9 Functional tests

Assemblies, such as switchgear and control gear assemblies, drives, controls, signs, luminaries and interlocks, shall be subjected to a functional test to show that they are properly mounted, adjusted and installed in accordance with the relevant requirements of these Electrical Requirements and with the relevant standard of the equipment or assemblies.

Protective devices shall be submitted to functional tests, if necessary, in order to check whether they are properly installed and adjusted.

NOTE Methods for verification of the operation of residual current protective devices are given as examples in Annex B.61.

61-2 Periodic Verification

After the initial verification, the periodic inspection and testing of the electrical installation should be carried out with a minimal interval, which is determine by the characteristics of installation, usage and environment. The maximum period between inspections may be laid down by National Statutory Requirements. (see Annex G.61).

Annex A.61
(normative)

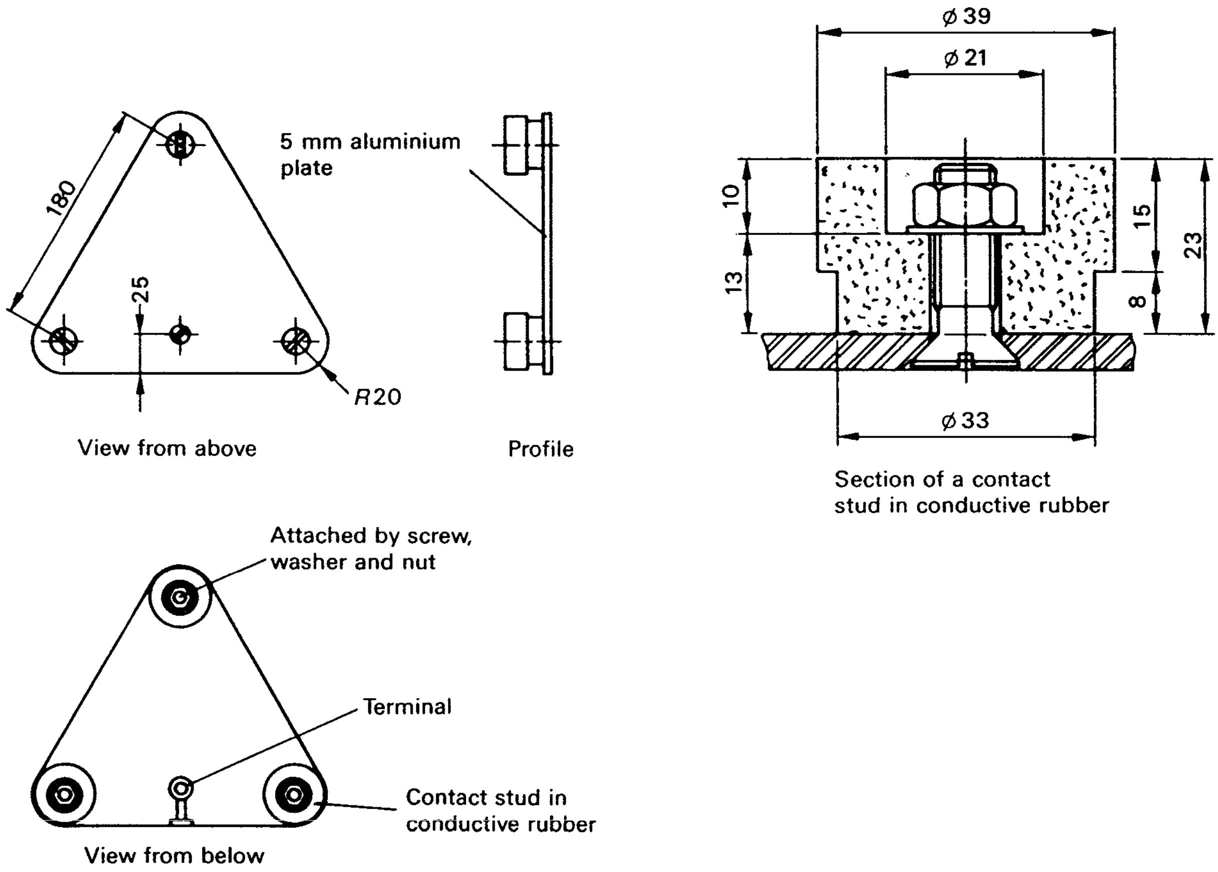
Method for Measuring the Insulation Resistance of Floors and Walls

A magneto-ohmmeter or battery-powered insulation tester providing a no-load voltage of approximately 500 V (or 1000 V if the rated voltage of the installation exceeds 500 V a.c.) is used as a d.c. source.
The resistance is measured between the test electrode and a protective conductor of the installation.
The test electrodes may be either of the following types. In case of dispute, the use of test electrode 1 is the reference method.

NOTE It is recommended that the test be made before the application of the surface treatment (varnishes paints and similar products).

Test electrode 1
The electrode comprises a square metallic plate with sides 250 mm and a square of damped water absorbent paper or cloth from which surplus water has been removed with sides approximately 270 mm which is placed between the metal plate and the surface being tested.
During the measurement a force of approximately 750 N or 250 N is applied on the plate, in the case of floors or of walls respectively.

Test electrode 2
The test electrode comprises a metallic tripod of which the parts resting on the floor form the points of an equilateral triangle. Each supporting part is provided with a flexible base ensuring, when loaded close contact with the surface being tested over an area of approximately 900 mm^2 and presenting a resistance of less than 5000 Ω.
Before measurements are made, the surface being tested is moistened or covered with a damp cloth. While measurements are being made a force of approximately 750 N or of 250 N is applied to the tripod, in the case of floors or of walls respectively.



Dimensions in millimeters

Figure A.61-1 Test electrode 2

Annex B.61
(normative)

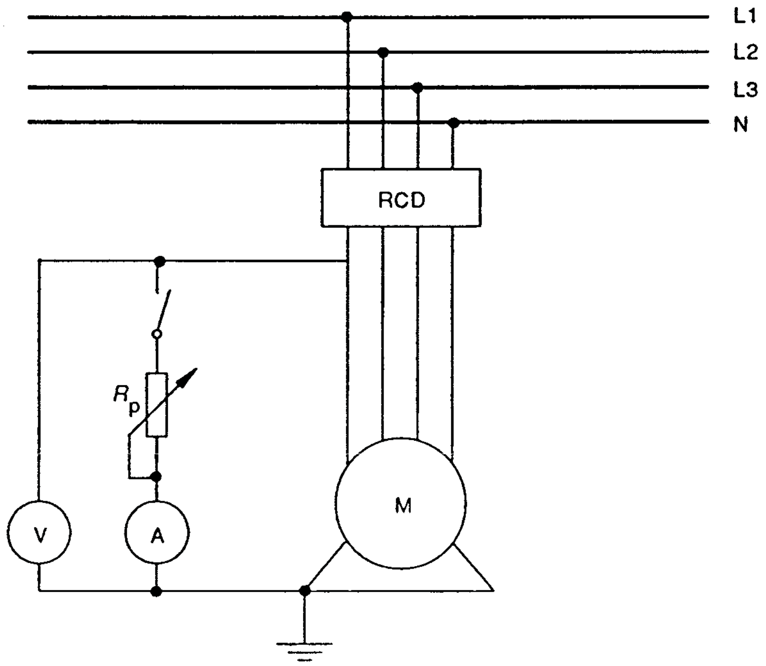
Verification of the Operation of Residual Current Protective Devices

The following methods are given as examples.

Method 1

Figure B.61-1 shows the principle of a method where a variable resistance is connected between a live conductor on the load side and the exposed-conductive-part. The current is increased by reducing the value of the variable resistance R_P.

The current I_Δ at which the RCD operates shall not be greater than $I_{\Delta n}$, the rated residual operating current.



NOTE Method 1 can be used for TN-S, TT and IT systems. In the IT system, it may be necessary to connect a point of the system directly to earth during the test to obtain the operation of the RCD.

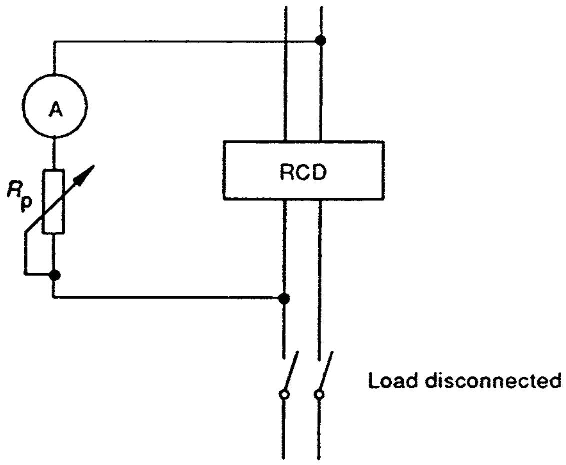
Figure B.61-1 Example of method 1

Method 2

Figure B.61-2 shows the principle of the method where the variable resistance is connected between a live conductor on the supply side and another live conductor on the load side.

The current is increased by reducing the value of the variable resistance R_P.

The current I_Δ at which the RCD operates shall not be greater than $I_{\Delta n}$. The load shall be disconnected during the test.



NOTE Method 2 can be used for TN-S, TT and IT systems.

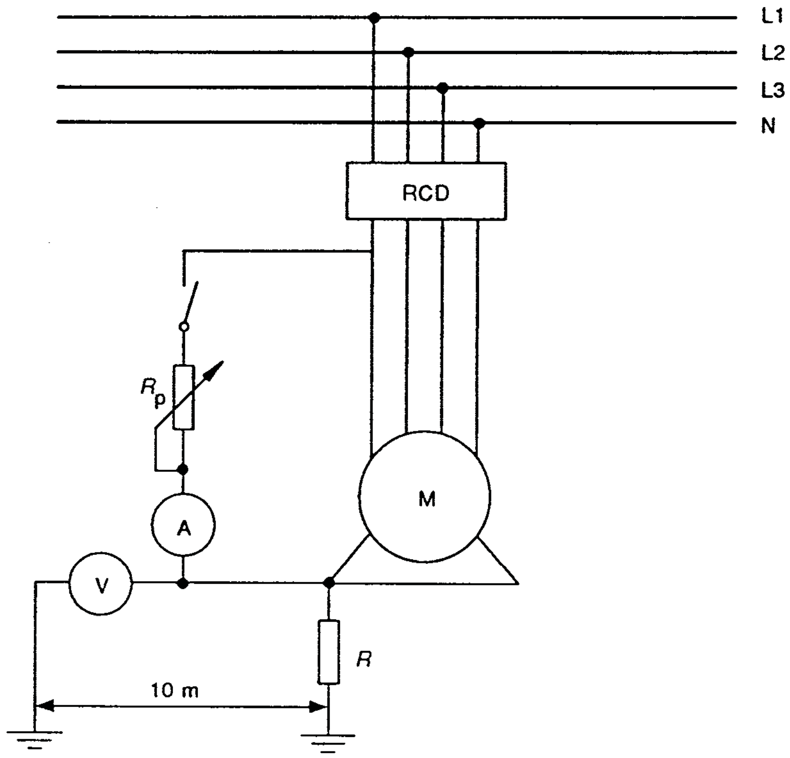
Figure B.61-2 Example of method 2

Method 3

Figure B.61-3 shows the principle of the method using an auxiliary electrode. The current is increased by reducing the value of the variable resistance R_P. Then the voltage U between the exposed-conductive-parts and an independent auxiliary electrode is measured. The current I_Δ, which shall not be greater than $I_{\Delta n}$ at which the RCD operates, is also measured.
The following condition shall be fulfilled:

$$U \leq U_L \times \frac{I_\Delta}{I_{\Delta n}}$$

where U_L is the conventional touch voltage limit.



NOTE 1 Method 3 can only be used when the location allows the auxiliary electrode.

NOTE 2 Method 3 can be used for TN-S, TT and IT systems. In IT systems it may be necessary to connect a point of the system directly to earth during the test to obtain the operation of the RCD.

Figure B.61-3 Example of method 3

Annex C.61
(normative)

Measurement of Earth Electrode Resistance

As an example, the following procedure may be adopted when the measurement of the earth resistance is to be made (see Figure C.61-1).

An alternating current of a steady value is passed between the earth electrode T and an auxiliary earth electrode T_1 placed at a distance from T such that the resistance areas of the two electrodes do not overlap.

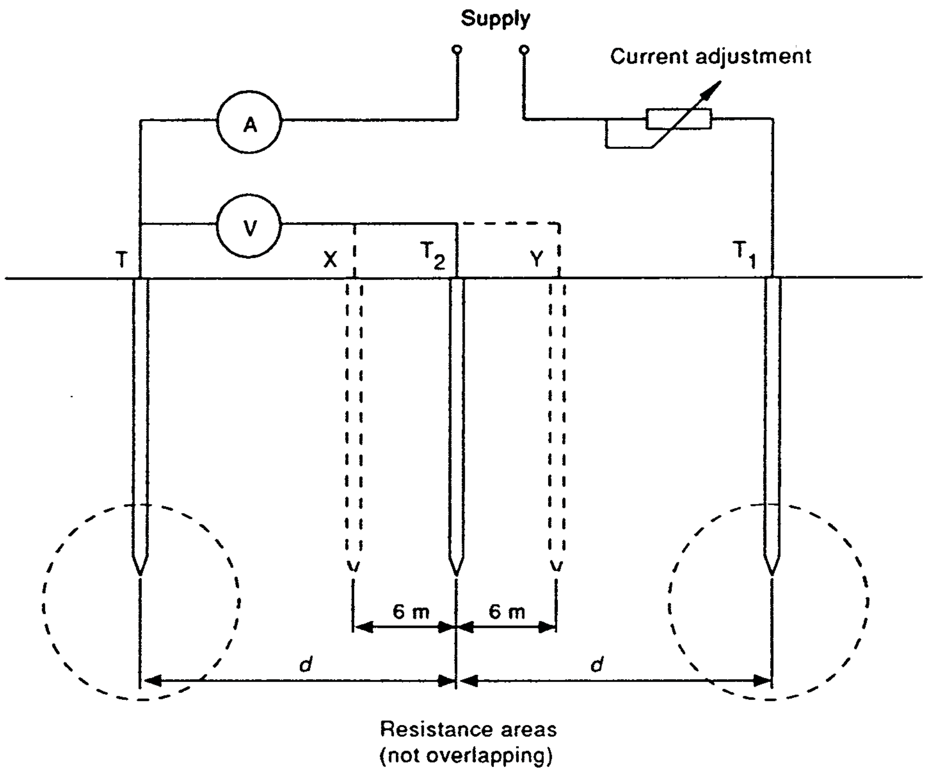
A second auxiliary earth electrode T_2, which may be a metal spike driven into the earth, is then inserted half-way between T and T_1, and the voltage drop between T and T_2 is measured.

The resistance of the earth electrodes is then the voltage between T and T_2, divided by the current flowing between T and T_1, provided that there is no overlap of the resistance areas.

To check that the resistance of the earth electrodes is a true value, two further readings are taken with the second auxiliary electrode T_2 moved some 6 m from and some 6 m nearer to T, respectively. If the three results are substantially in agreement, the mean of the three readings is taken as the resistance of the earth electrode T. If there is no such agreement, the tests are repeated with the distance between T and T_1 increased.

If the test is made with current at power frequency, the internal impedance of the voltmeter used must be at least 200 Ω/V.

The source of the current used for the test shall be isolated from the mains supply (e.g. by a double-wound transformer).



Key

T Earth electrode under test, disconnected from all other sources of supply

T_1 Auxiliary earth electrode

T_2 Second auxiliary earth electrode

X Alternative position of T_2 for check measurement

Y Further alternative position of T_2 for the other check measurement

Figure C.61-1 Measurement of earth resistance

Annex D.61
(normative)

Measurement of the Fault Loop Impedance

As examples, the following methods may be adopted for TN systems when the measurement of fault loop impedances is to be made.

NOTE 1 The methods proposed in this annex give only approximate values of the fault loop impedance as they do not take into account the vectorial nature of the voltage, i.e. of the conditions existing at the time of an actual earth fault. The degree of approximation is, however, acceptable provided that the reactance of the circuit concerned is negligible.

NOTE 2 It is recommended to make a continuity test (see 61-1.2.2) between the neutral point and the exposed conductive parts before carrying out the fault loop impedance measurement.

Method 1: Measurement of the fault loop impedance by means of voltage drop

NOTE 1 Attention is drawn to the fact that the present method presents difficulties in the application.

The voltage of the circuit to be verified is measured with and without connection of a variable load resistance (see Figure D.61-1), and the fault loop impedance is calculated from the formula:

$$Z = \frac{U_1 - U_2}{I_R}$$

Where:

Z is the fault loop impedance;

U_1 is the voltage measured without connection of the load resistance;

U_2 is the voltage measured with connection of the load resistance;

I_R is the current through the load resistance.

NOTE 2 The difference between U_1 and U_2 should be significant.

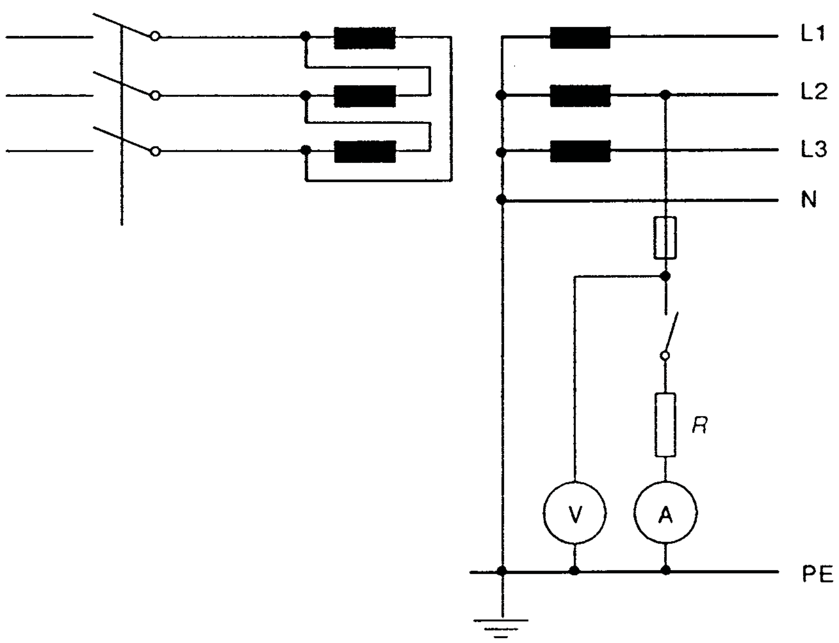


Figure D.61-1 Measurement of fault loop impedance by impedance drop

Method 2: Measurement of the fault loop impedance by means of a separate supply
The measurement is made when the normal supply is disconnected and the primary of the transformer is short-circuited. The method uses a voltage from a separate supply (see Figure D.61-2), and the fault loop impedance is calculated from the formula:

$$Z = \frac{U}{I}$$

Where:
Z is the fault loop impedance;
U is the measured test voltage;
I is the measured test current.

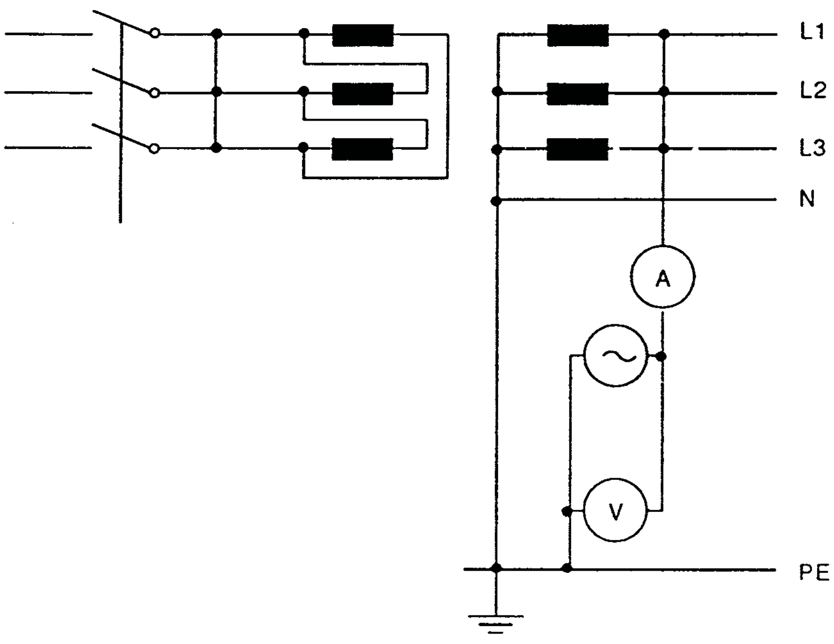


Figure D.61-2 Measurement of fault loop impedance by separate supply

Annex E.61
(informative)

Guide on the Application of the Rules of this Chapter
Initial Verification

The numbering of the sections and statements of this Annex E.61 follows the numbering of the corresponding sections and statements of this Chapter.
The absence of reference of sections or statements means that no additional explanation is given to them.

E.61-1.1 Visual inspection

E.61-1.1.1 This verification is intended also to check that the installation of the equipment is in accordance with the manufacturer's instructions in order that its performance is not adversely affected.

E.61-1.1.3

Second dash of 61-1.1.3

a) Presence of fire barriers (52-7.2) and other precautions against propagation of fire and protection against thermal effects (52-7.2.7 and 52-7.2.1).
The installation of the seals is verified to confirm compliance with the erection instructions associated with relevant type test for the product.
No other test is required after this verification.

b) Protection against thermal effects (Chapters 42 and 43).
The rules of Chapter 42 concerning the protection against thermal effects apply for normal service, i.e. in the absence of a fault.
The overcurrent protection of wiring systems is the object of Chapter 43 and 53-3 of Chapter 53.
The operation of a protective device resulting from a fault, including short-circuits, or from overloads, is considered as normal service.

c) Protection against fire (42-2 of Chapter 42).
The requirements of 42-2 for locations with fire hazards assume that protection against overcurrent is in compliance with the rules of Chapter 43.

Third and fourth dashes of 61-1.1.3

Selection of conductors for current-carrying capacity and voltage drop and choice and setting of protective and monitoring devices.
The selection of the conductors including their materials, installation and cross-sectional area, their erection and the setting of the protective devices is verified according to the calculation of the designer of the installation in compliance with the rules of these Electrical Requirements, particularly Chapters 41, 43, 52, 53 and 54.

Eighth dash of 61-1.1.3

Presence of diagrams, warning notices or other similar information.
A diagram, as specified by 51-4.4 of Chapter 51, is particularly necessary when the installation comprises several distribution boards.

Tenth dash of 61-1.1.3

Adequacy of connections of conductors.
The purpose of this verification is to check whether the clamping means are adequate for the conductors to be connected and whether the connection is properly made.

In case of doubt, it is recommended to measure the resistance of the connections: this resistance should not be higher than the resistance of a conductor having a length of 1 m and a cross-sectional area equal to the smallest cross-sectional area of the conductors connected.

Eleventh dash of 61-1.1.3

Accessibility for convenience of operation identification and maintenance.

It shall be verified that the operating devices are so arranged that they are easily accessible to the operator.

For devices for emergency switching (including emergency stopping), see 53-6.4.2 of Chapter 53.

For devices for switching off for mechanical maintenance, see 53-6.3.2 of Chapter 53.

E.61-1.2 Tests

NOTE Information on the requirements of measuring and monitoring equipment is given in the series of Saudi Standards.

E.61-1.2.1 Continuity of protective conductors, including the main and supplementary equipotential bonding

This test is required for the verification of the protection conditions by means of automatic disconnection of supply (see 61-1.2.6) and is considered as satisfactory if the device used for the test gives an appropriate indication.

NOTE The current used for the test should be low as not to cause a risk of fire or explosion.

E.61-1.2.2 Insulation resistance of the electrical installation

The measurements shall be carried out with the installation isolated from the supply.

Generally the insulation measurement is carried out at the origin of the installation.

If the value measured is less than that specified in Table 61-1, the installation may be divided into several circuit groups and the insulation resistance of each group shall be measured. If for one group of circuits the measured value is less than that specified in Table 61-1, the insulation resistance of each circuit of this group shall be measured.

When some circuits or parts of circuits are disconnected by under-voltage devices (for instance contactors) interrupting all live conductors, the insulation resistance of these circuits or parts of circuits is measured separately.

If some appliances are connected, it is permitted to carry out the measurement between live conductors and earth.

If, in this case, the value measured is less than that specified in Table 61-1, these appliances shall then be disconnected and the measurement repeated.

E.61-2.3 Protection by separation of circuits

When equipment includes both a separated circuit and other circuits, the required insulation is obtained by constructing the equipment in accordance to the safety requirements of the relevant standards.

In the case of a fixed separation source, it should be verified that its secondary circuits are separated by a double or reinforced insulation from its enclosure (for mobile sources, see 41-3.5.1.1 of Chapter 41), unless the separation source is adequately marked.

E.61-1.2.4 Verification of conditions for protection by automatic disconnection of the supply

E.61-1.2.4.1 Measurement of fault loop impedance

Annex D.61 describes, as examples, methods for the measurement of the fault loop impedance.

a) *(of 61-1.2.6.3) Consideration of the increase of the resistance of the conductors with the increase of temperature*

As the measurements are made at room temperature, with low currents, the procedure hereinafter described may be followed to take into account the increase of resistance of the conductors with the increase of temperature due to faults, to verify, for TN systems, the compliance of the measured value of the fault loop impedance with the requirements of 41-3.1.3 of Chapter 41.

The requirements of 41-3.1.3 are considered to be met when the measured value of the fault loop impedance satisfies the following equation:

$$Z_s(\mathrm{m}) \le \frac{2}{3} \times \frac{U_o}{I_a}\ (\Omega)$$

Where:

Z_S(m) is the measured value of phase-earthed neutral loop impedance, in ohms;

U_O is the phase to earthed neutral voltage, in volts;

I_a is the current causing the automatic operation of the protective device within the time stated in Table 41-1 from Chapter 41 or within 5 s according to the conditions stated in 41-3.1.3.

Where the measured value of the fault loop impedance exceeds $2U_O/3I_a$, a more precise assessment of compliance with 41-3.1.3 may be made evaluating the value of the fault loop impedance according to the following procedure:

- the supply phase-earthed neutral loop impedance, Z_e, is first measured at the origin of the installation;
- the resistance of the phase and protective conductor of the distribution circuit(s) are then measured;
- the resistances of the phase and protective conductor of the final circuit is then measured;
- the values of these resistances are increased on the basis of the increase of the temperature, taking into consideration, in the case of fault currents, the energy let-through of the protective device;
- these increased values of the resistance are finally added to the value of the supply phase-earthed neutral loop impedance, Z_e, so obtaining a realistic value of Z_S under fault conditions.

b) *(of 61-1.2.6.3) Measurement of the resistance of protective conductors*

The measurement of the fault loop impedance may be replaced by the measurement of the resistance *R* between any exposed-conductive-part and the nearest point of the main equipotential bonding, under all the following conditions:

- the protective conductor is contained in the same wiring system as the phase conductors, with no ferromagnetic parts interposed (so rendering the relevant reactance negligible);

  NOTE Protective conductors include metal conduits and other metal enclosures for conductors in the conditions defined in 54-3.2.

- the cross-section of the PE conductors does not exceed 95 mm² Cu.

It is recommended that the measurement be carried out with a supply having a no-load voltage of 4 V to 24 V, a.c. or d.c., and with a minimum current of 0.2A.

The measured resistance *R* shall meet the following conditions:

1) when the impedance of the supply is negligible:

$$R \leq \frac{m}{m+1} \times \frac{U_o}{I_a}$$ for TN systems

$$R \leq \frac{m}{m+1} \times \frac{U}{2I_a}$$ for IT systems where the neutral is not distributed

$$R \leq \frac{m}{m+1} \times \frac{U_o}{2I_a}$$ for IT systems where the neutral is distributed

Where:

U_o is the nominal voltage between phase and neutral, in volts;

U is the nominal voltage between phases, in volts;

I_a is the current ensuring the automatic operation of the disconnecting protective device within the time stated in Tables 41-1 from Chapter 41, for TN systems, or tables 41-2 from Chapter 41, for IT systems, or, under the conditions stated in 413.3.5, within 5 s;

m is the ratio between R and R_{ph}:

$$m = \frac{R}{R_{ph}}$$

Where:

R_{ph} is the resistance of the phase conductor placed in the same wiring as the protective conductor;

R is the resistance of the protective conductor between any exposed-conductive-part and the nearest point of the main equipotential bonding.

NOTE The above condition to be met by the measured resistance *R* is justified, for example in the case of a TN system, by replacing the fault loop impedance Z_s by R_s and writing:

$$R_s = R + R_{ph} = R\left(1 + \frac{1}{m}\right) = R\,\frac{m+1}{m}$$

The condition to be met by the fault loop impedance (according to 41-3.1.3.3, for TN systems) may then be written as follows:

$$I_a \leq \frac{U_o}{R_s} = \frac{U_o}{R} \times \frac{m}{m+1}$$

Or as follows:

$$R \leq \frac{m}{m+1} \times \frac{U_o}{I_a}$$

When $m = 1$, the condition to be met becomes:

$$R \leq \frac{U_o}{2I_a}$$

With m increasing, the value, which is admitted for the measured resistance R also increases.

For example when $m = 2$, the condition to be met becomes:

$$R \leq \frac{U_o}{1.5I_a}$$

2) when the impedance of the supply side is not negligible:
For example, for TN systems

$$R \leq \frac{0{,}8 \times m}{m+1} \times \frac{U_o}{I_a}$$

NOTE The factor 0.8 is a conventional value based on the ratio, that experience has shown as valid in the majority of cases, between the impedance of the protected circuit and the impedance of the fault loop. If the actual value of the above ratio is known, the factor 0.8 is to be replaced by that actual value.

Annex F.61
(informative)

Verification of the Lightning Protection Systems LPS

F.61-1 Frequency of Inspections

All new lightning protection systems must be inspected following completion of their installation. However, it is also very important to make periodic inspections of existing systems. The interval between inspections should be determined by such factors as the following:

- Classification of structure or area protected;
- Level of protection afforded by the system;
- Immediate environment (corrosive atmospheres);
- Materials from which components are made;
- Type of surface to which the lightning protection components are attached;
- Trouble reports or complaints.

In addition to the above, a lightning protection system should be inspected whenever any alterations or repairs are made to a protected structure, as well as following any known lightning discharge to the system.

It is recommended that lightning protection systems be visually inspected at least annually. In some areas where severe climatic changes occur it may be advisable to visually inspect systems semiannually or following extreme changes in ambient temperatures. Complete, in-depth inspections of all systems should be completed every three to five years. It is recommended that critical systems be inspected every one to three years depending on occupancy or the environment where the protected structure is located.

In most geographical areas, and especially in areas that experience extreme seasonal changes in temperature and rainfall, it is advisable to stagger inspections so that earth resistance measurements, for example, are made in the hot, dry months as well as the cool, wet months. Such staggering of inspections and testing is important in assessing the effectiveness of the lightning protection system during the various seasons throughout the year.

F.61-2 Visual Inspection

Visual inspections are made to ascertain the following:

- The system is in good repair.
- There are no loose connections that might result in high-resistance joints.
- No part of the system has been weakened by corrosion or vibration.
- All down conductors and earth terminals are intact (non-severed).
- All conductors and system components are securely fastened to their mounting surfaces and are protected against accidental mechanical displacement as required.
- There have not been additions or alterations to the protected structure that would require additional protection.
- There has been no visual indication of damage to surge suppression (over voltage) devices.
- The system complies in all respects with Chapter 802.

F.61-3 Testing

The following tests shall be carried out:

- Tests to verify continuity of those parts of the system that were concealed (built-in) during the initial installation and that are not now available for visual inspection.
- Earth resistance tests of the earth termination system and its individual earth electrodes if adequate disconnecting means have been provided. These test results should be compared with previous or original results or current accepted values, or both, for the soil conditions involved. If it is found that the test values differ substantially from previous values obtained under the same test procedures, additional investigations should be made to determine the reason for the difference.
- Continuity tests to determine if suitable equipotential bonding has been established for any new services or constructions that have been added to the interior of the structure since the last inspection.

F.61-4 Maintenance

Maintenance of a lightning protection system is extremely important even though the lightning-protection design engineer has taken special precautions to provide corrosion protection, and has sized the components according to their particular exposure to lightning damage. Many system components tend to lose their effectiveness over the years because of corrosion factors, weather-related damage, and stroke damage. The physical, as well as the electrical, characteristics of the lightning protection system must be maintained in order to maintain compliance with design requirements as per Chapter 802.

F.61-5 Report

On the occasion of every periodic inspection and testing a report must be prepared, which should include, in addition to all information concerning the visual inspections and the tests made, records of the relevant results, information about any modifications or extensions and any non-compliance with the rules, specifying the parts of the installation concerned.

The inspector or inspection body should compile and maintain reports pertaining to the following:

- General condition of air terminals, conductors, and other components;
- General condition of corrosion-protection measures;
- Security of attachment of conductors and components;
- Resistance measurements of various parts of the ground terminal system.

Annex G.61
(informative)

Periodic Inspection and Testing

G.61-1 General

Periodic inspection and testing of the electrical installations is carried out to determine if the installations and parts of the installations have not deteriorated to the extent that renders them unsafe to use and is in compliance with the installation rules, unless otherwise required by national rules or by national statutory requirements.

In addition it includes the examination of the effects of any change in use of the premises from that for which the installation was previously provided.

NOTE The guidance information given for initial verification is in principle valid also for periodic inspection and testing.

G.61-2 Interval between periodic inspection and testing

After the initial verification, the periodic inspection and testing of the electrical installations should be carried out with a minimal interval, which is determined by the characteristics of the installation, usage and environment. The maximum period between inspections may be laid down by national statutory requirements.

NOTE 1 The interval may be, for instance, five years, with the exception of the following cases where a higher risk may exist and shorter periods may be required:

- working places or locations where risks of degradation, fire or explosion exist;
- working places or locations where both high- and low-voltage installations exist;
- communal facilities;
- construction sites;
- locations where portable equipment is used.

For dwelling, longer periods may be appropriate.

NOTE 2 Periodic inspection and testing may be replaced, in case of extended electrical installations (e.g. in large industries), by an adequate safety regime of continuous monitoring and maintenance of equipment and installations by skilled persons.

G.61-3 Extent of the periodic inspection and testing

The periodic inspection and testing should include at least:

- visual inspection, including the protection against direct contact and protection against fire;
- test of the insulation resistance;
- test for continuity of the protective conductors;
- tests for protection against indirect contact;
- functional test of RCDs, see Annex B.61.

G.61-4 Report

On the occasion of every periodic inspection and testing a report must be prepared, which should include, in addition to all information concerning the visual inspections and the tests made, records of the relevant results, information about any modifications or extensions and any non-compliance with the rules, specifying the parts of the installation concerned (see NOTE 1).

NOTE 1 The following is an Example of the test report format.

Test Report

Report Number: ………………………………	File Number:…………………………………
Inspection Body: …………………………	Contractor :…………………………………
Construction Details & Address: …………………………………………………………………	
Tick ☑ in the appropriate box : C (Conforming) – NC (Not Confirming). Tick ☒ if Not Applicable	

Inspection Details			C	NC
Visual Inspection [61-1.1]				
Protection against direct Contact[41-0.3.2]			☐	☐
Present of diagrams, warning notices, etc [51-4]			☐	☐
a) Insulation of live parts[41-2.1]			☐	☐
b) Barriers or enclosures [41-2.2]			☐	☐
c) Obstacles[41-2.3]			☐	☐
d) Placing Out of reach[41-2.4]			☐	☐
Protection of Fire Propagation & Thermal Effects [42,5-27]			☐	☐
C.S.A Selection of Live Conductors [52-3]				
Application	Minimum	Actual[mm2]		
Fixed lighting Circuits [10 A]	1.5 mm^2	………..	☐	☐
Socket-outlets circuits [15 A]	2.5 mm^2	………..	☐	☐
20 A circuits	4 mm^2	………..	☐	☐
30 A circuits and A/C circuits	6 mm^2	………..	☐	☐
Other kind of circuits	…… mm^2	………..	☐	☐
C.S.A Selection of Protective Conductors		………..	☐	☐
Main Equipotential bonding conductor		………..	☐	☐
Earth Conductors		………..	☐	☐
All socket-outlets provided with Earth Conductor			☐	☐
Wet areas Socket-outlets protected by RCD≤30mA			☐	☐
Water Areas Electrical Installations			☐	☐
Chose & Setting of protective devices [53]			☐	☐
Selection appropriate to external influences [51-2,42-2&52-2]			☐	☐
Identification of circuits, breakers, N, PE, etc [51-4]			☐	☐
Adequacy of connections of conductors [52-6]			☐	☐
Accessibility for operation & Maintenance[51-3]			☐	☐
Conformity of the installation material			☐	☐

Test Details	C	NC
Depends on Earthing System:		
☐ TN-C ☐ TN-S ☐ TN-C-S ☐ TT ☐ IT		
Continuity of protective conductors[61-1.2.2]…….Ω	☐	☐
Resistance of earth electrode[61-1.2.6.6]…………….Ω	☐	☐
Fault Loop Impedance [61-1.2.6.3]…….. ………….Ω	☐	☐
Insulation resistance (whole installation)MΩ:[61-1.2.3]		
a) Between live conductors……………………MΩ	☐	☐
b) Between each live conductor & Earth ……MΩ	☐	☐
Insulation resistance (separated circuits) to Verify Separation of circuits [61-1.2.4] …………………… M Ω	☐	☐
Polarity Test[61-1.2.7]	☐	☐
Operation of RCD ≤ 30mA	☐	☐
Operation of RCD ≤ …… mA	☐	☐
Functional Tests [61-2.9]	☐	☐
To be tested If Applicable:	☐	☐
Floor and wall resistance [61-2.5] in average……… MΩ	☐	☐
Electric strength test [61-1.2.8]	☐	☐
Lightning Protection Systems Verification[802]	☐	☐
Luminaries Verification[55-9]	☐	☐
Electric signs Verification[730]	☐	☐
Comments:		

Inspected by: Signature:

Next Periodic Report

Witnessed by: Signature:

Schedules: This report is valid only when the following Schedules attached to it:[Enter Quantities & Pages of schedules attached]

………Inspection Schedules………Pages,………Test result Schedules ………Pages & other………Schedules………Pages.

(C.S.A): Cross-sectional Area. (N) : Neutral.(PE) : Protective Earth. (RCD) Residual Current Devices.

PART SEVEN

SPECIAL LOCATIONS AND INSTALLATIONS

CHAPTER 701
LOCATIONS CONTAINING A BATHTUB OR SHOWER BASIN

701:11 Scope

The particular requirements of this chapter apply to bath tubs, shower basins, and the surrounding zones where the risk of electric shock is increased by a reduction in body resistance and contact of the body with earth potential.

These requirements do not apply to an enclosed prefabricated shower cabinet with its own shower basin and drainage system, except for item b) of 701:53.

NOTE For locations containing baths or showers for medical treatment, special requirements may be necessary.

701:32 Classification of zones

These requirements are based on the dimensions of four zones (see Figures 701-1, 701-2 and 701-3);

a) Zone 0

is the interior of the bath tub or shower basin;

In a location containing a shower without a basin, zone 0 is limited by the floor and by the plane 0.05 m above the floor. In this case:

- where the shower head is demountable and able to be moved around in use, Zone 0 is limited by the vertical plane(s) at a radius of 1.2 m measured horizontally from the water outlet at the wall.
- where the shower head is not demountable, Zone 0 is limited by the vertical plane(s) at a radius of 0.6 m measured horizontally from the shower head.

b) Zone 1

Zone 1 is limited by:

i) the upper plane of Zone 0; and

ii) the horizontal plane 2.25 m above the floor; and

iii) the vertical plane(s) circumscribing the bath tub or shower basin and includes the space below the bathtub or shower basin where that space is accessible without the use of a tool, or

- for a shower without a basin and with a demountable shower head able to be moved around in use, the vertical plane(s) at a radius of 1.2 m from the water outlet at the wall, or
- for a shower without a basin and with a shower head which is not demountable, the vertical plane(s) at a radius of 0.6 m from shower head.

c) Zone 2

Zone 2 is limited by:

i) the floor; and

ii) the horizontal plane 2.25 m above the floor; and

iii) the vertical plane(s) external to zone 1; and

iv) the vertical plane(s) 0.6 m external to zone 1; and

v) the space above zone 1 up to the ceiling (where the ceiling height exceeds 2.25 m) or a height 3.0 m above the floor, whichever is lower.

d) Zone 3

Zone 3 is limited by:

i) the floor; and

ii) the horizontal plane 2.25 m above the floor; and
iii) the vertical plane(s) external to zone 2; and
iv) the vertical plane(s) 2.4 m external to zone 2; and
v) the space above zone 2 up to the ceiling (where the ceiling height exceeds 2.25 m) or a height 3.0 m above the floor, whichever is lower.

The dimensions are measured taking account of walls and fixed partitions (see Figures 701-1, 701-2 and 701-3).

701:41 Protection against electric shock

NOTE For protection of socket-outlets, see Item a) of 701:53.

701:41-0.3 Application of protective measures against electric shock

701:41-0.3.1 In Zone 0, only protection by safety extra-low-voltage at a nominal voltage not exceeding 12 V a.c or 30 V dc is permitted, the safety source being installed outside the zone.

701:41-0.3.2 The measures of protection by means of obstacles (41-2.3 of Chapter 41) and by placing out of reach (41-2.4 of Chapter 41) are not permitted.

701:41-0.3.3 The measures of protection by non-conducting location (41-3.3 of Chapter 41) and by earth-free equipotential bonding (41-3.4 of Chapter 41) are not permitted.

701:41-1.1.3.7 Where safely extra-low-voltage is used, whatever the nominal voltage, protection against direct contact shall be provided by:

- barriers or enclosures affording at least the degree of protection IP2X, or
- insulation capable of withstanding a test voltage of 500 V for 1 min.

701:41-3.1.6 Supplementary equipotential bonding

A local supplementary equipotential bonding shall connect all extraneous conductive parts in Zones 1, 2 and 3 with protective conductors of all exposed conductive parts situated in these zones.

701:51 Common rules

701:51-2.2 Electrical equipment shall have at least the following degrees of protection:

In Zone 0:	IPX7	
In Zone 1:	IPX5	IPX5 in public baths (Zones 1 and 2)
In Zone 2:	IPX4	
In Zone 3:	IPX1	

701:52 Wiring systems

701:52-0.1 The following rules apply to surface wiring systems and to wiring systems embedded in the walls at a depth not exceeding 5 cm.

701:52-0.2 The wiring systems shall provide insulation satisfying the requirements of 41-3.2 without any metallic covering.

NOTE Such wiring may consist for example of single-core cables in insulating conduits or multicore cables with insulating sheath.

701:52-0.3 In Zones 0, 1 and 2, wiring systems shall be limited to those necessary to the supply of situated in those zones.

701:52-0.4 Junction boxes are not permitted in Zones 0, 1 and 2.

701:53 Switchgear and controlgear

a) In Zones 0, 1 and 2, no switchgear and accessories shall be installed.

NOTE Insulating cords of cord-operated switches are admitted in Zones 1 and 2, provided that they comply with the requirements of SASO IEC 60669-1: Switches for Household and Similar Fixed-electrical Installations – Part 1: General Requirements.

In Zone 3, socket-outlets are permitted only if they are:

- either supplied individually by an isolating transformer complying with 41-3.5.1,
- or supplied by safety extra-low-voltage (41-1.1 of Chapter 41),
- or protected by a residual current protective device with a residual operating current $I_{\Delta n}$ not exceeding 30 mA.

b) Any switches and socket-outlets shall be at a distance of at least 0.60 m from the door opening of the prefabricated shower cabinet (see Figure 701-4).

701:55 Other equipment

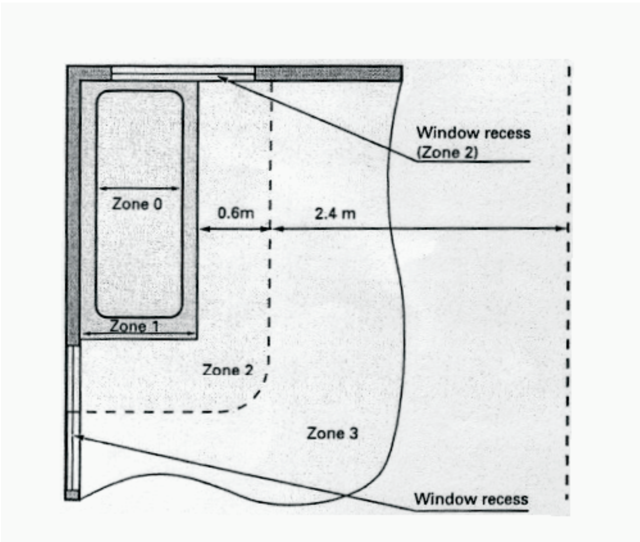
These requirements do not apply to supplied at safety extra-low-voltage according to the conditions of 41-1.1 of Chapter 41 and 701:41-1.1.3.7.

In Zone 0, only electrical specially intended for use in a bath tub are permitted.

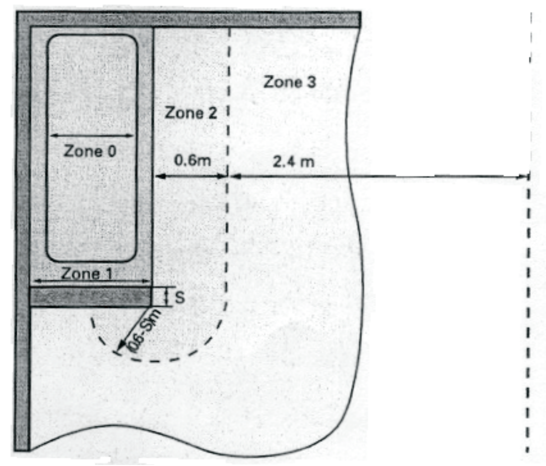
In Zone 1, only water heaters may be installed.

In Zone 2, only water heaters and Class II luminaires may be installed.

Heating units embedded in the floor and intended for heating the location may be installed in all zones provided that they are covered by a metallic grid or by an earthed metallic sheath connected to the equipotential bonding specified in 701:41-3.1.6.

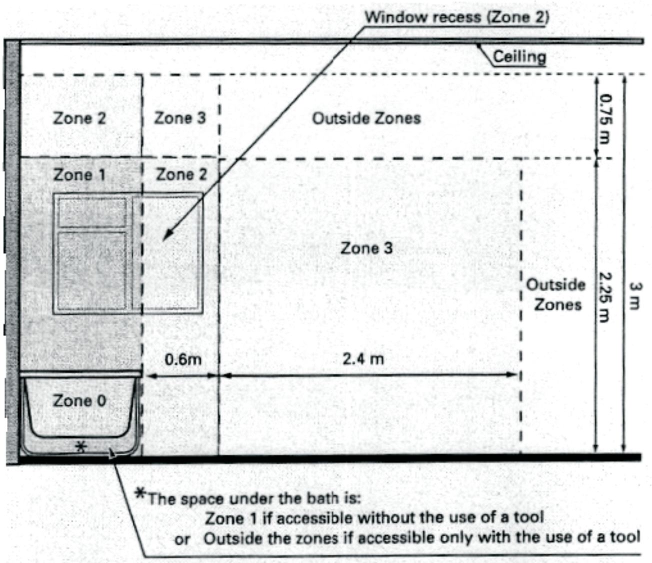


a) Bath tub (plan)



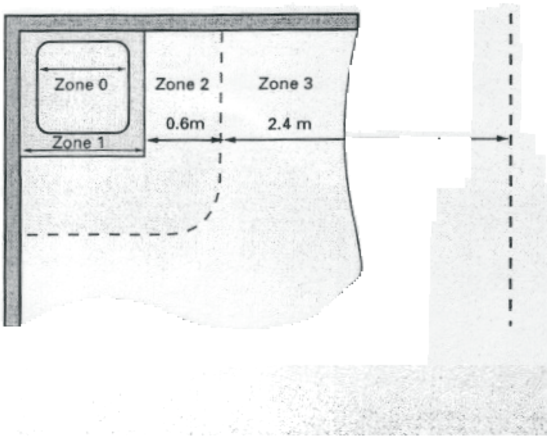
S: thickness of partition

b) Bath tub with permanently fixed partition (plan)

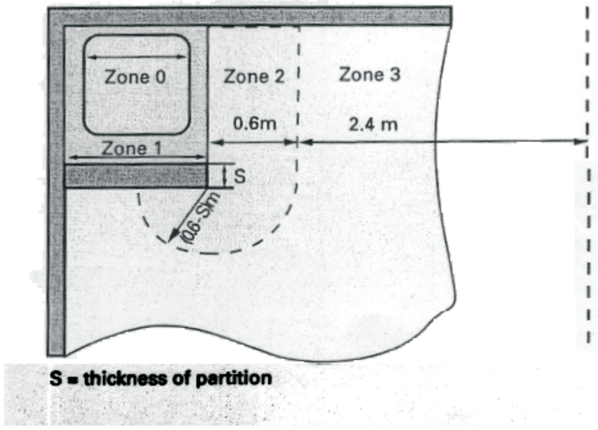


c) Bath tub (elevation)

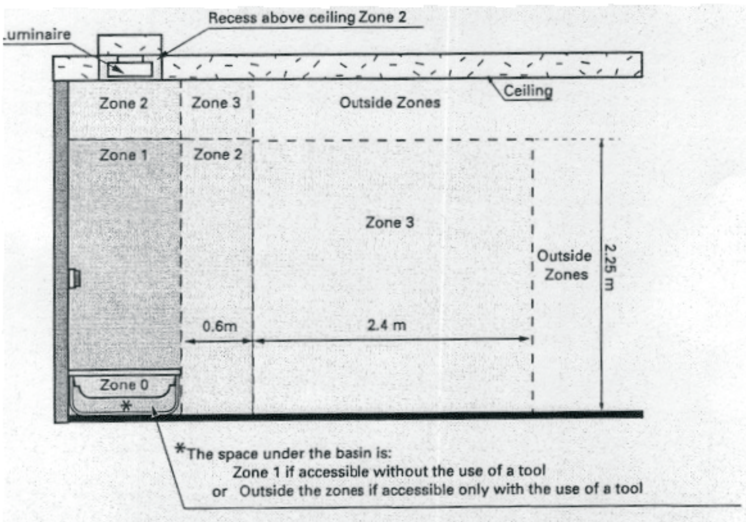
Figure 701-1 Zone Dimensions for Bath Tub



a) Shower basin (plan)

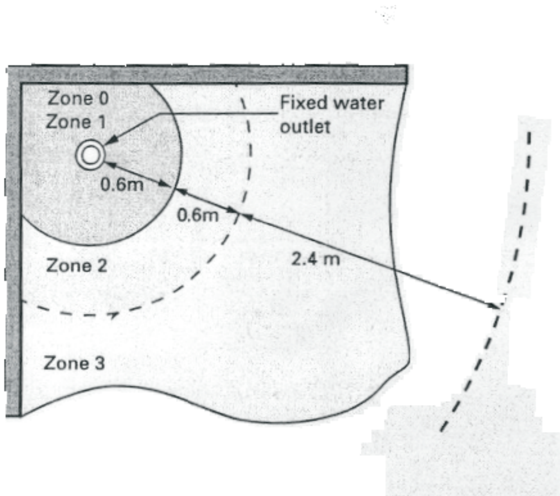


b) Shower basin with permanently fixed partition (plan)

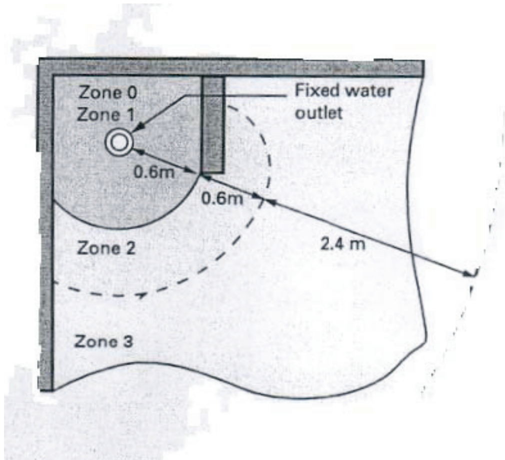


c) Shower basin (elevation)

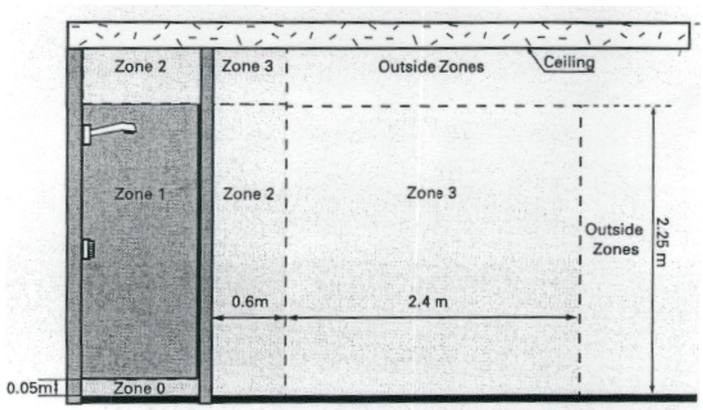
Figure 701-2 Zone Dimensions for Shower basin



a) Shower without basin (plan)

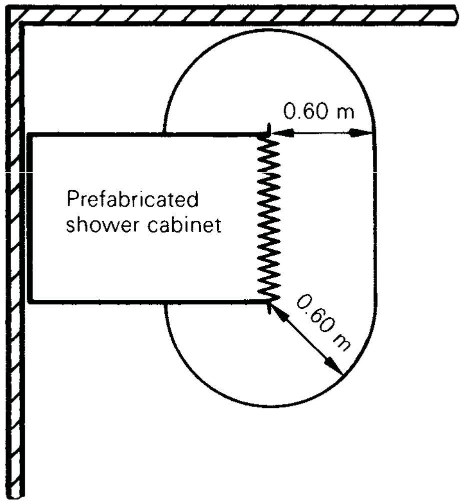


b) Shower without basin with permanently fixed partition fixed water outlet not demountable (plan)



c) Shower without basin with permanently fixed partition fixed water outlet not demountable (elevation)

Figure 701-3 Zone Dimensions for Shower without basin



Application of Item b) of 701:53

Figure 701-4 Prefabricated Shower Cabinet

CHAPTER 702
SWIMMING POOLS AND OTHER BASINS

702:11 Scope

The particular requirements of this chapter apply to the basins of swimming pools, the basins of fountains and the basins of paddling pools. They also apply to the surrounding zones of all these basins. In these areas, in normal use, the effect of an electric shock is increased by a reduction in body resistance and contact of the body with earth potential.

The requirements for swimming pools are applicable for paddling pools.

For swimming pools for medical use, special requirements may be necessary.

702:32 Classification of external influences

These requirements are based on the dimensions of three zones (examples are given in Figures 702-1, 702-2, 702-3, 702-4 and 702-5).

a) **Zone 0**

This Zone is the interior of the basins including any recesses in their walls or floors and basins for foot cleaning or the interior of waterjets or waterfalls.

b) **Zone 1**

This Zone is limited by:

- the upper plane of Zone 0;
- the vertical plane(s) external to Zone 0;
- the vertical plane(s) 2 m from the rim of the basin;
- the floor or the surface expected to be occupied by persons;
- the horizontal plane 2.5 m above the floor or the surface, except where the basin is above earth, when it shall be 2.5 m above the level of the rim of the basin.

When the swimming pool contains diving boards, spring boards, starting blocks, chutes or other components expected to be occupied by persons, Zone 1 comprises the zone limited by:

- the vertical plane(s) situated 1.5 m around the diving boards, spring boards, starting blocks, chutes and other components such as accessible sculptures and decorative basins;
- the horizontal plane 2.5 m above the highest surface intended to be occupied by persons.

c) **Zone 2**

This zone is limited by:

- the vertical plane(s) external to Zone1
- the vertical plane(s) 1.5m from Zone 1
- the floor or surface intended to be occupied by
- the horizontal plane 2.5 m above that floor or surface.

There is no Zone 2 for fountains.

702:41 Protection against electric shock

NOTE 1 For protection of socket-outlets, see also 702:53.

NOTE 2 For protection of other equipment, see also 702:55.

702:41-0.3 Application of measures of protection against electric shock

702:41-0.3.5 Particular requirements for each zone

702:41-0.3.5.1 General

With the exception for fountains mentioned in 702:47-1.3.2 in Zones 0 and 1, only protection by SELV at a nominal voltage not exceeding 12 V a.c. or 30 V d.c. is permitted, the safety source being installed external to Zones 0, 1 and 2 (see also 702:53 and 702:55).

Equipment for use in the interior of basins which are only intended to be into operation when people are outside Zone 0 shall be supplied by circuits protected either by:

- SELV (see 41-1.1 of Chapter 41), the safety source being installed outside Zones 0, 1 and 2; or
- automatic disconnection of the supply (see 41-3.1 of Chapter 41), using a residual current protective device with a rated residual operating current not exceeding 30 mA; or
- electrical separation (see 41-3.5 of Chapter 41), the separation source supplying only one item of equipment being installed external to Zones 0, 1 and 2.

The socket-outlets of circuits supplying such equipment and the control device of such equipment shall have a notice, in order to warn the user that this equipment shall be used only when the swimming pool is not occupied by persons.

702:41-0.3.5.2 Zones 0 and 1 of fountains

In zones 0 and 1 the following protective measures only shall be employed:

- SELV (see 41-1.1 of Chapter 41), the safety source being installed outside Zones 0 and 1; or
- automatic disconnection of supply (see 41-3.1 of Chapter 41) using a residual current protective device with a rated residual operating current not exceeding 30 mA; or
- electrical separation (see 41-3.5 of Chapter 41), the separation source supplying a single item of equipment and being installed external to Zones 0 and 1.

702:41-0.3.5.3 Zone 2

NOTE There is no Zone 2 for fountains.

One or more of the following protective measures shall be employed:

- SELV (see 41-1.1 of Chapter 41), the safety source being installed outside of Zones 0, 1 and 2;
- automatic disconnection of supply (see 41-3.1 of Chapter 41) using residual current protective devices with a rated residual operating current not exceeding 30 mA;
- Electrical separation (see 41-3.5 of Chapter 41); the separation source supplying a single item of equipment and being installed outside Zones 0, 1 and 2.

702:41-1.1.4 Requirements for unearthed circuits (SELV)

702:41-1.1.4.3 Where SELV is used, whatever the nominal voltage, protection against direct contact shall be provided by:

- barriers or enclosures affording at least the degree of protection according to SASO 980 IP2X or IPXXB, or

- insulation capable of withstanding a test voltage of 500 V a.c. for 1 min.

702:41-2.3 Protection by obstacles

Protection by obstacles is not applicable.

702:41-2.4 Protection by placing out of reach

Protection by placing out of reach is not applicable.

702:41-3.1.6 Supplementary equipotential bonding

All extraneous conductive parts in Zones 0, 1 and 2 shall be connected by local equipotential bonding conductors and connected to the protective conductor of the exposed conductive parts of equipment situated in these zones. This requirement is not to be applied to equipment supplied by SELV circuits. Where there is a metal grid in a solid floor it shall be connected to the local supplementary bonding.

NOTE 1 This connection with the protective conductor may be provided in close proximity to the location, for example at an accessory or a distribution board or other equipment.

NOTE 2 See also 702:55.1.

702:41-3.3 Protection by non-conducting locations

Protection by non-conducting locations is not applicable.

702:41-3.4 Protection by earth free local equipotential bonding

Protection by earth free local equipotential bonding is not applicable.

702:51 Common rules

702:51-2.2 External influences

Electrical equipment shall have at least the following degrees of protection according to SASO 980:

- Zone 0: IPX8;
- Zone 1: IPX5

but for swimming-pools inside buildings which normally are not cleaned by means of water jets:

IPX4;

- Zone 2: IPX2 for indoor locations;
  IPX4 for outdoor locations;
  IPX5 where water jets are likely to occur for cleaning purposes.

702:52 Wiring systems

702:52-0 General

The following rules apply to surface wiring systems and to wiring systems embedded either in the walls or in floors at a depth not exceeding 5 cm.

702:52-2 Selection and erection in relation to external influences

702:52-2.21 Erection according to the zones

In Zones 0, 1 and 2, wiring systems shall not have accessible metallic covering. Metallic covering which are inaccessible shall be connected to the supplementary equipotential bonding.

NOTE Cables should preferably installed in conduits made of insulating material.

702:52-2.22 Limitation of wiring systems according to the zones

In Zones 0 and 1, wiring systems shall be limited to those necessary to supply equipment situated in these zones.

702:52-2.23 Additional requirements for the wiring of fountains

For fountains, the following additional requirements shall be met:

a) Cables for electrical equipment in Zone 0 shall be installed as far outside the basin rim as possible and run up to the electrical equipment inside the basin by the shortest possible route. The cables shall be installed in conduits to facilitate rewiring.

b) In zone 1, cables shall be installed with suitable mechanical protection.

Only cables of type SASO IEC 60245 or of a type with at least equivalent properties shall be used. Their suitability for permanent contact with water shall be declared by the manufacturer in addition to compliance with SASO 595 and SASO 598.

702:52-2.24 Junction boxes

Junction boxes shall not be installed in Zones 0 and 1, except in Zone 1, where permitted for SELV circuits.

702:53 Isolation, switching and control

In Zones 0 and 1, no switchgear or controlgear, including socket-outlets, shall be installed.

For small swimming-pools where it is not possible to locate socket-outlets and switches outside zone 1, socket-outlets and switches, having non metallic covers or cover plates, are permitted in zone 1 if they are installed outside arms reach (1.25 m) from the Zone 0 border, and placed at least 0.3 m above the floor, and they shall be protected either by:

- SELV (see 41-1.1 of Chapter 41), at a nominal voltage not exceeding 25 V a.c. a.c. or 60 V d.c., the safety source being installed outside Zones 0 and 1; or
- automatic disconnection of supply using a residual current protective device with a rated residual operating current not exceeding 30 mA; or
- electrical separation (see 41-3.5 of Chapter 41), individually, the separation source being external to Zones 0 and 1.

In Zone 2, socket-outlets and switches are permitted only if the circuits supplying them are protected by one of the following protective measures:

- by SELV (see 41-1.1 of Chapter 41), the safety source being installed outside Zones 0, 1 and 2;
- by automatic disconnection of supply (see 41-3.1 of Chapter 41) using a residual current protective device with rated operating current not exceeding 30 mA;
- by electrical separation (see 41-3.5 of Chapter 41) supplied individually by the separation source which is installed external to Zones 0, 1 and 2.

702:55 Other equipment

702:55-1 Current-using equipment of swimming pools

In Zone 0 and 1, only fixed current-using equipment especially intended for use in swimming-pools may be installed, taking into account the requirements of 702:55-2 and 702:55-4.

Appliances, which are intended to be in operation only when people are outside the Zone 0 may be used in all zones provided that they are supplied by circuits protected according to 702:41-0.3.5.

Heating units embedded in the floor may be installed, provided that they are:

- protected by SELV (see 41-1.1 of Chapter 41), the safety source being installed outside Zones 0, 1 and 2; or
- covered by an embedded earthed metallic grid or by an embedded earthed metallic sheath connected to the supplementary equipotential bonding specified in 702:41-3.1.6 provided that their supply circuits are additionally protected by a residual current device with a rated residual operating current not exceeding 30 mA.

702:55-2 **Underwater lighting of swimming pools**

Luminaires for use in the water or in contact with the water shall comply with SASO IEC 60598-2-18.

Underwater lighting located behind watertight portholes, and serviced from behind shall comply with the appropriate of Saudi Standards and be installed in such a way that no intentional or unintentional conductive connection between any exposed-conductive-part of the underwater lighting fittings and any conductive parts of the portholes can occur.

702:55-3 **Electrical equipment of fountains**

Electrical equipment in Zones 0 and 1 shall be inaccessible, e.g. by use of mesh glass or by grids which can only be removed by tools.

The luminaires in Zones 0 and 1 shall be fixed and shall comply with SASO IEC 60598-2-18.

Electric pumps shall comply with the requirements of SASO IEC 60335-2-41.

702:55-4 Special requirements for the installation of low-voltage electrical equipment in Zone 1 of swimming pools and also other basins**.**

Fixed equipment especially intended for use in swimming pools and other basins (e.g. filtration groups, jet stream) supplied through LV other than SELV at the nominal voltage not exceeding 12 V a.c. or 30 V d.c. are allowed in Zone 1 with of all the following requirements:

a) They shall be located in an enclosure equivalent to a supplementary insulation providing the protection against mechanical impact AG2.

NOTE This statement applies independently from the classification of equipment. Class I equipment is connected to a protective conductor.

b) They shall only be accessible via a hatch (or a door) by means of a key or a tool. The opening of the hatch (or door) shall disconnect all live conductors. The supply cable and the main shall be of class II construction or installed in a way which provides equivalent protection.

c) When the hatch (or the door) is opened, the degree of protection provided by equipment shall be at least IPXXB.

d) The supply circuit of this equipment shall be protected:

- either by SELV at a nominal voltage not exceeding 25 V a.c or 60 V d.c., the safety source being installed outside Zones 0, 1 and 2,
- or by a residual current device with a rated operating current not exceeding 30 mA (see 41-2.5 of Chapter 41),
- or by electrical separation (see 41-3.5.1 of Chapter 41), the separation source being installed outside Zones 0, 1 and 2.

For small swimming pools where it is not possible to locate luminaires outside zone 1, luminaires in zone 1 are permitted, if they are installed outside arms' reach from the Zone 0 border (1.25 m) and

- either they are protected by SELV,
- or they are protected by residual current protective devices with a rated residual operating current not exceeding 30 mA,
- or they are protected by electrical separation (see 41-3.5 of Chapter 41), the separation source being installed outside the Zones 0 and 1.

In addition, the luminaires shall have an enclosure providing class II or equivalent insulation and with mechanical protection of AG2.

Annex A.702
(informative)

Summary of Principal Protection Requirements

Table A.702-1 Applicable protective measures according to the zones

Zones[1)]		Protective measure				
		SELV with maximum voltage[2)]	Electrical separation Number of items of equipment	Automatic disconnection of supply	Reference	Degree of protection[3)]
Zone 0	A [2)]	12 V a.c. or 30 V d.c.	Not applicable	Not applicable	702 :41-0.3.5.1	IPX8
	B	50 V a.c. or 120 V d.c. [5)]	1	RCD ≤ 30 Ma	702 :41-0.3.5.2	
	C [2)]	50 V a.c. or 120 V d.c.	1	RCD ≤ 30 mA	702 :41-0.3.5.1	
Zone 1	A [2)]	12 V a.c. or 30 V d.c.	Not applicable	Not applicable	702 :41-0.3.5.1	IPX5/4
	B	50 V a.c. or 120 V d.c.	1	RCD ≤ 30 mA	702 :41-0.3.5.2	
	E	25 V a.c. or 60 V d.c.	1	RCD ≤ 30 mA	702 :53	
Zone 2	A	50 V a.c. or 120 V d.c.	1	RCD ≤ 30 mA	702 :41-0.3.5.3	IPX2/4/5
	B [4)]	Not relevant	Not relevant	Not relevant	702 :32	
	D	50 V a.c. or 120 V d.c.	1	RCD ≤ 30 mA	702 :53	

1) A General
B For fountains only
C Circuits supplying equipment for use in the interior of basins when people are outside the zone 0
D Socket-outlets and switches
E Socket-outlets and switches in small swimming pools

2) See also 702 :41-1.1.4.3 and, for the location of the safety source, 702 :41-0.3.5.1.

3) See 702 :51-2.2.

4) Not defined for fountains.

5) For luminaires, limited to 12 V a.c. or 30 V d.c.

Table A.702-2 Selection and erection of equipment according to the zones

	Equipment permitted in Zone 0	**Equipment permitted in Zone 1**	**Equipment permitted in Zone 2**	**Reference**	**Remarks**
Wiring systems	See 702 :52-2			702 :52-2	
Junction boxes	No	No See remarks	Yes	702 :52-2.24	Accepted in Zone 1 for SELV circuits where permitted
Switchgear and controlgear (socket-outlets and swiches, excepted)	No	No	Yes	702 :53 [1]	
Socket-outlets and switches	No	Yes See remarks	Yes See remarks	702 :53 [1]	For small swimming pools in Zone 1: at least 1.25 m arms' reach from zone 0, and at least 0.3 m above the floor. In zone 2, Special protective measures shall be applied
Other equipment:					
– intended for use in swimming pools	Yes	Yes	Yes	702 :55-1	Special design
– heating units embedded in the floor	Not relevant	Yes	Yes	702 :55-1	Protected by SELV or coverd by an embedded earthed metallic grid
– underwater lighting	Yes	Not applicable	Not applicable	702 :55-2	Special requirements
– for fountains	Yes	Yes	Not defined	702 :55-3	Special requirements in Zones 0 and 1
– fixed equipment installed in Zone 1	Not applicable	Yes	Not applicable	702 :55-4	Special requirements. For luminaires. see below
– luminaires installed in Zone 1	Not applicable	Yes See remarks	Not applicable	702 :55-4	Special requirements

[1] See also table A.702-1.

CHAPTER 703
LOCATIONS CONTAINING SAUNA HEATERS

703:11 **Scope**

The particular requirements of this chapter apply to locations in which sauna heating equipment is installed and exclusively reserved for such use.

703:41 **Protection against electric shock**

703:41-0.3 **Application of protective measures against electric shock**

703:41-0.3.1 The measures of protection against direct contact by means of obstacles (see 41-2.3) and by placing out of reach (see 41-2.4) are not permitted.

703:41-0.3.2 The measures of protection against indirect contact by non-conducting location (see 41-3.3) and by earth-free equipotential bonding (see 41-3.4) are not permitted.

703:41-1.1.3.7 Where safety extra-low-voltage is used, whatever the nominal voltage, protection against direct contact shall be provided by:

- barriers or enclosures affording at least the degree of protection IP2X , or
- insulation capable of withstanding a test voltage of 500 V a.c. for 1 min.

703:51 **Common rules**

703:51-2.2 The equipment shall have at least the degree of protection IP24.

Four zones are defined as shown in Figure 703-1:

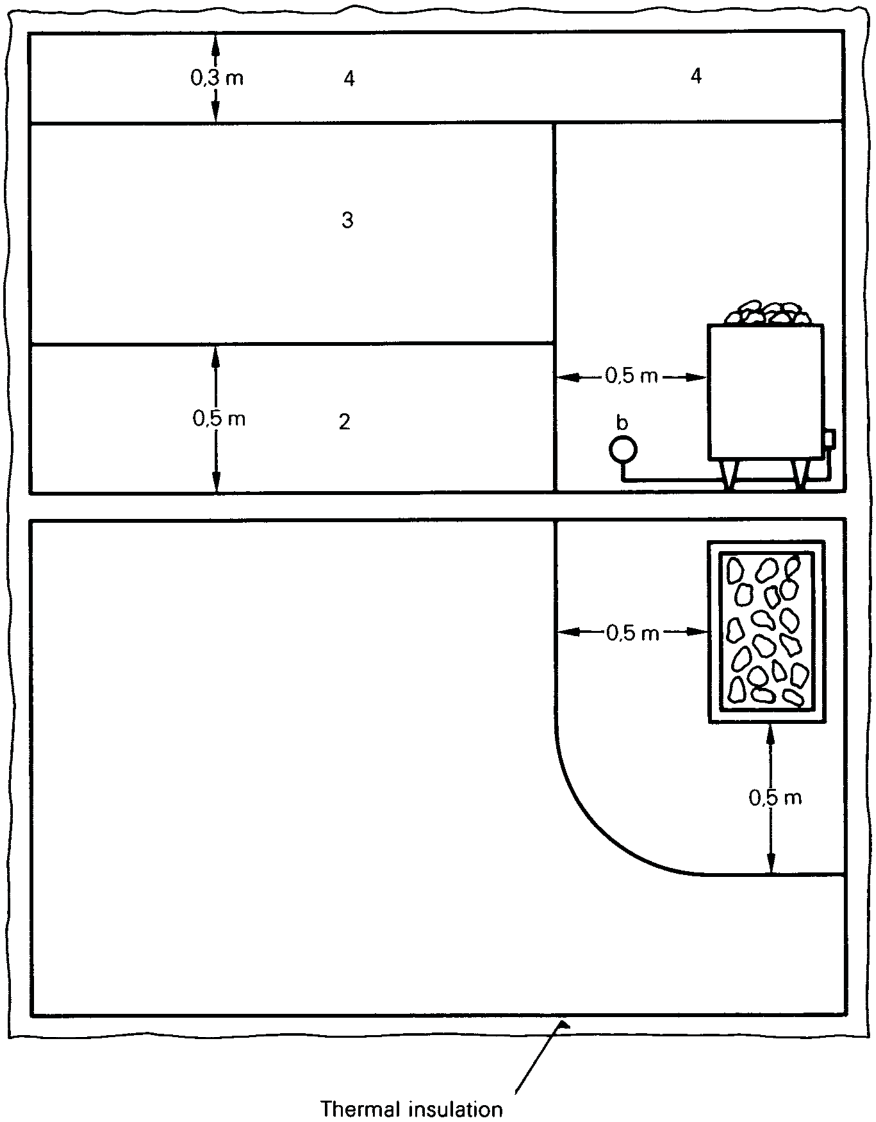
- Zone 1 in which only equipment belonging to the sauna heater shall be installed;
- Zone 2 for which there is no special requirement concerning heat resistance of equipment;
- Zone 3 in which the equipment shall withstand a minimum temperature of 125°C and the insulation of wires shall withstand a minimum temperature of 170°C;
- Zone 4 in which only luminaires and their associate wiring, control devices of sauna heaters (thermostats and thermal cut-outs) and wiring belonging to those devices shall be installed. Heat resistance shall be as required for Zone 3.

703:52 **Wiring systems**

The wiring systems shall provide insulation satisfying the requirements of 41-3.2 without any metallic sheath or metallic conduit.

703:53 **Isolation, switching and control**

- Switchgear not built into the sauna heater shall be placed outside the enclosure of the location.
- Socket-outlets shall not be installed.
- A temperature limiting device shall be installed, capable of disconnecting the supply to the sauna heater when the temperature measured in Zone 4 (see Figure 703-1) exceeds 140°C.



b = connection box

Figure 703-1 Zones of ambient temperature

CHAPTER 704
CONSTRUCTION AND DEMOLITION OF SITE INSTALLATIONS

704:11 Scope

704:11.1 The special requirements of this chapter shall apply to temporary installations provided for the purpose of electricity supply during the execution of the following works:

- new building construction;
- repair, alteration, extension, or demolition of existing buildings;
- engineering constructions;
- earthworks;
- similar works.

The rules of this chapter do not apply to installations covered by SASO IEC 60621, or to other installations where equipment of a similar nature to that used in surface mining applications is involved.

Parts of buildings which undergo structural alterations, such as extension, major repair or demolition are considered to be like construction sites during the period of relevant works, to the extent that the work necessitates the provision of a temporary installation.

For the administrative locations of construction sites (offices, cloakrooms, meeting rooms, canteens, restaurants, dormitories, toilets, etc.) the general rules of these Electrical Requirements apply.

NOTE For special situations, more severe requirements apply, e.g. Chapter 706 for restrictive conductive locations.

704.1.5 In construction sites, fixed installations are limited to the assembly comprising the main controlgear and the principal protective devices (see 704:53-7).

Installations on the load side are considered as movable installations except for parts which are designed according to Chapter 52.

704:31 Purposes, supplies and structure

704:31-3 Supplies

704:31-3.1.3 Equipment shall be identified with the particular supply from which it is energized, and shall contain only components connected to one and the same installation, except for control or signalling circuits and input from standby supplies.

NOTE One construction site may be served by several sources of supply, including fixed or mobile power generators.

704:41 Protection against electric shock

704:41-0.3 Measures of protection against electric shock

In addition to 41-0.3 the following rules shall apply:

When protection of persons against indirect contact is provided by the measure of protection by automatic disconnection of supply appropriate to the type of earthing system (41-3.1 of Chapter 41), the conventional voltage limit U_L shall be limited to 25 V a.c or 60 V d.c.

NOTE Protection by reduced low-voltage system in which the highest voltage shall not exceed 110 V a.c. between phases and 55 V a.c. to earth (single phase) or 63.5 V a.c. to earth (three phases) is considered as a particular application of the protection measure by automatic disconnection of supply in the TN system

according to 41-3.1 of chapter 41. In this case, socket-outlets do not need the additional protective measures specified below.

Socket-outlets shall either be protected by residual current devices having rated operating current not exceeding 30 mA (41-2.5 of Chapter 41) or be supplied at safety extra-low-voltage (41-1.1 of Chapter 41), or have electrical separation of circuits, each socket-outlet being supplied by a separate transformer (41-3.5 of Chapter 41).

704:41-3 **Protection against indirect contact**

704:41-3.1 **Protection by automatic disconnection of supply**

704:41-3.1.5 **IT systems**

Where IT systems are used, permanent earth fault monitoring shall be provided.

704:51 Common rules

704:51-1.1 All assemblies for distribution of electricity on construction and demolition sites shall comply with the requirements of SASO 2041.

704:51-2.2 Fixed equipment and installation equipment (e.g. couplers) shall have a degree of protection appropriate to the external influences but not less than IP44.

Assemblies for construction sites shall have degrees of protection as specified in SASO 2041.

Other equipment shall have degrees of protection according to external influences.

704:52 Wiring systems

704:52-1.1.7.3 Wiring shall be so arranged that no strain is placed on the terminations of conductors unless they are specially designed for this purpose.

Conductors shall only be permitted within cable assemblies; or cords or cables for hard usage.

To avoid damage, cables should not be run across site roads or walkways. Where this is necessary special protection against mechanical damage and contact with construction plant shall be provided.

Temporary wiring shall be removed immediately upon completion of construction or purpose for which the wiring was installed.

704:53 Isolating, switching and control

704:53-7 **Devices for isolation and switching**

At the origin of each installation, an assembly comprising the main controlgear and the principal protective devices shall be provided.

A device or devices shall be provided on the incoming cable to each supply assembly and each distribution assembly for switching and isolating.

Means of emergency switching shall be provided on the supply to all current-using equipment on which it may be necessary to disconnect all live conductors in order to remove a hazard.

The isolating and protective devices of distribution circuit may be contained in the main assembly or in separate assemblies fed from the main assembly.

Incoming power isolating devices shall be suitable for securing in the off position (see 41-2.2 of Chapter 41) (for example, a padlock or location inside a lockable enclosure).

The supply to current-using apparatus shall be effected by distribution assemblies, each assembly comprising:

- overcurrent protective devices;
- devices affording protection against indirect contact;
- socket-outlets.

Safety and standby supplies shall be connected by means of devices arranged to prevent interconnection of the different supplies.

704:53-8 **Plugs and socket-outlets**

Socket-outlets shall be arranged either:

- Inside the assemblies as incorporated as part of an assembly as described in 704:53-7;
- Outside on the walls of such assemblies;
- Every plug and socket-outlet shall comply with SASO IEC 60309-2.

704:55-9 All lamps for general lighting shall be protected from accidental contact by a suitable fixture or lamp holder with a guard.

CHAPTER 705
ELECTRICAL INSTALLATIONS OF AGRICULTURAL AND HORTICULTURAL PREMISES

705:11 Scope

The particular requirements of this chapter apply to all parts of fixed installations of agricultural and horticultural premises outdoors and indoors and to locations where livestock are kept (such as stables, chicken-houses, piggeries, feed-processing locations, lofts and storages for hay, straw and fertilizers).

705:41 Protection against electric shock

705:41-1.1.4.3 Where safety extra-low-voltage is used, whatever the nominal voltage, protection against direct contact shall be provided by:

- barriers or enclosures affording at least the degree of protection IP2X, or IPXXB,or
- insulation capable of withstanding a test voltage of 500 V a.c for 1 min.

705:41-2.5 Circuits with socket-outlets,except those supplied from safety extra-low-voltage supply, shall be protected by residual current operated protective device having a rated operating residual current not exceeding 30 mA.

705:41-3.1 For the application of the protective measure against indirect contact by automatic disconnection of supply, the conventional voltage limit in locations in which livestock are present or situated outside is U_L = 25 V a.c. or 60 d.c. and the maximum disconnecting time is that indicated in Table 41-3.

These conditions are also applicable to locations directly connected through extraneous conductive parts to the locations where livestock are kept.

705:41-3.1.6 In a location for livestock, supplementary equipotential bonding shall connect all exposed conductive parts and extraneous conductive parts which can be touched by livestock, and the protective conductor of the installation.

NOTE A metallic grill laid in the floor and connected to the protective conductor is recommended.

705:42 Protection against thermal effects

705:42-1 Protection against fire

For fire protection purposes, a residual current protective device having a rated operating residual current not exceeding 0.5 A, shall be installed for the supply to equipment other than essential to the welfare of livestock.

Heating for the raising of livestock shall be fixed to maintain an appropriate distance from livestock and combustible material to avoid any risk of burns to livestock and fire.

For radiant heaters, the clearance shall be at least 0.5 m unless a wider clearance is specified by the manufacturer of the apparatus in the instructions for use.

705:42-2 Measures for Protection against fire

NOTE 1 Due consideration shall be given to the evacuation of the animals in case of emergency and the rules of 42-2.2 of Chapter 42 may be applicable.

NOTE 2 In the locations where risk of fire exists, the rules of 42-2.3 of Chapter 42 apply.

705:51 Common rules

705:51-2 Electrical equipment shall have at least the degree of protection IP45.

705:53 Isolation, switching and control

705:53-2.2

NOTE It is recommended to protect final sub-circuits by a residual current device with a rated operating residual current not exceeding 30 mA and as low as practicable and avoiding nuisance tripping.

705:53-7 Devices for isolation and switching

Devices for emergency switching including emergency stopping shall not be installed where they are accessible to livestock or in any position where access to them may be impeded by livestock, account being taken of the conditions likely to arise in the event of panic by livestock.

705:55 Other equipment

NOTE 1 Where electric fences are in the vicinity of overhead lines, appropriate distances should be observed to take account of induction currents, falling lines, etc.

NOTE 2 For large-scale livestock keeping, Chapter 32 and 55-6 should be considered, especially for live support systems for livestock.

CHAPTER 706
RESTRICTIVE CONDUCTING LOCATIONS

706:11 Scope

The particular requirements of this chapter apply to installations for restrictive conducting locations and to the supply to apparatus within these locations.

A restrictive conducting location is one comprised mainly of metallic or conductive surrounding parts, within which it is likely that a person will come in contact through a substantial portion of his body with the conductive surrounding parts and where the possibility of interrupting this contact is limited.

706:41 Protection against electric shock

706:41-0.1.3.7 Where safety extra-low-voltage is used, whatever the nominal voltage, protection against direct contact shall be provided by:

- barriers or enclosures affording at least the degree of protection IP2X or IPXXB or
- insulation capable of withstanding a test voltage of 500 V a.c. for 1 min.

706:41-0.3 Application of measures of protection against electric shock

706:41-0.3.2 Application of measures of protection against direct contact

The measures of protection by means of obstacles (41-2.3 of Chapter 41) and by placing out of reach (41-2.4 of Chapter 41) are not permitted.

706:41-0.3.3 Application of measures of protection against indirect contact

Only the following protective measures are permitted:

a) For the supply to hand-held tools and portable measuring equipment:

- safety extra-low-voltage (41-1.1 of Chapter 41), or
- electrical separation (41-3.5 of Chapter 41) subject to one item of equipment only being connected to a secondary winding of the isolating transformer. Class II equipment shall preferably be used. Where Class I equipment is used, that equipment shall be provided with at least a handle of insulating material or a handle with insulating lining.

NOTE An isolating transformer may have several secondary windings.

b) For the supply to handlamps:

- safety extra-low-voltage (41-1.1 of Chapter 41).
- a fluorescent luminaire with built-in double-wound transformer supplied at safety extra-low-voltage is equally permitted.

c) For the supply to fixed equipment:

- either automatic disconnection of the supply (41-3.1 of Chapter 41); a supplementary equipotential bonding (41-3.1.6 of Chapter 41) shall connect exposed conductive parts of fixed equipment and the conductive parts of the location,
- or safety extra-low-voltage (41-1.1 of Chapter 41),

- or electrical separation (41-3.5 of Chapter 41) subject to one item of equipment being connected to a secondary winding of the isolating transformer.

706:41-0.3.3.5 Safety sources and isolating sources shall be situated outside the restrictive conducting location, except as provided in Item b) of 706:41-0.3.3.

706:41-0.3.3.6 If a functional earth is required for certain fixed equipment, for example measuring and control apparatus, equipotential bonding shall be provided between all exposed conductive parts, all extraneous conductive parts inside the restrictive conducting location, and the functional earth.

CHAPTER 707
EARTHING REQUIREMENTS FOR THE INSTALLATION OF DATA PROCESSING EQUIPMENT

707:11 Scope

NOTE Radio-frequency interference suppression filters fitted to data processing equipment may produce high earth leakage current, in such cases failure of continuity in the protective earth connection may cause a dangerous touch voltage. The main purpose of this chapter is to prevent this hazard.

The particular requirements of this chapter apply to the connection of data processing equipment to the electrical power installation of buildings, where the data processing equipment:

- has earth leakage current exceeding the limit specified in SASO 3288 : Safety of Data Processing Equipment, for equipment connected via a plug and socket complying with SASO 444 : Plugs and Socket-outlets for Domestic and Similar General Use. Standards, or similar;
- complies with those requirements of SASO 3288 which cover leakage current.

The requirements of this chapter apply to the installation up to the point of connection of the equipment (see Figure A.707-1).

These requirements may also be applied where installations, other than data processing, such as those for industrial control and telecommunications equipment carry high leakage current due to radio-frequency interference suppression filtering requirements.

707:41 Protection against electric shock

707:41-0.3 Additional protection against electric shock for equipment with high leakage current

707:41-0.3.1 The requirements of this statement apply where equipment having high leakage current is connected to any type of power system. These requirements apply to the installation as shown in Figure A.707-1.

Additional requirements are given for TT and IT systems in 707:41-0.4 and 707:41-0.5 respectively.

NOTE 1 On TN-C systems where the neutral and protective conductors are connected in a single conductor (PEN conductor) up to the equipment terminals, leakage current may be treated as load current.

NOTE 2 Equipment normally having high earth leakage current may not be compatible with installations incorporating residual current protective devices. As well as the standing residual current due to leakage current, the possibility of nuisance tripping due to capacitor charging currents at switch-on shall be considered.

707:41-0.3.2 Equipment shall be:

- stationary, and
- either permanently connected to the building wiring installation or connected via industrial plugs and sockets.

NOTE 1 Plugs and sockets complying with SASO IEC publication SASO IEC 60309-1: Plugs, Socket-outlets and Couplers for Industrial Purposes. Part 1: General Requirements are examples of suitable plugs and sockets. Plugs and sockets for general use, such as those conforming to IEC publication 60083 are not suitable.

NOTE 2 It is particularly important for equipment with high leakage current, that earth continuity should be checked, as required by Chapter 61 of these Electrical Requirements at the time it is installed and after any modification to the

installation. It is also recommended that earth continuity be checked thereafter at regular intervals.

707:41-0.3.3 Further requirements for Installations having leakage currents exceeding 10 mA

Where leakage current measured in accordance with SASO 3288 exceeds 10 mA, equipment shall be connected in accordance with one of the three alternative requirements detailed in 707:41-0.3.3.1, 707:41-0.3.3.2 and 707:41-0.3.3.3.

NOTE Leakage current measurements prescribed by SASO 3288 include likely undetected fault conditions within the equipment.

707:41-0.3.3.1 High-integrity protective (earth) circuits

NOTE The aim of these requirements is to provide high-integrity protective circuits by using robust or duplicate conductors in association with permanent connections or robust connectors.

Protective conductors shall have the greater cross-sectional area resulting from compliance with Chapter 43 or the following:

a) Where independent protective conductors are used there shall be one conductor with a cross-sectional area of not less than 10 mm^2 or two conductors with independent terminations, each having a cross-sectional area of not less than 4 mm^2.

NOTE Conductors of 10 mm^2 or greater cross-sectional area may be aluminium

b) When incorporated in a multicore cable together with the supply conductors, the sum total cross-sectional area of all the conductors shall be not less than 10 mm^2.

c) Where the protective conductor is installed in, and connected in parallel with a rigid or flexible metal conduit having electrical continuity in accordance with SASO IEC publication 60614-2-1 a conductor of not less than 2.5 mm^2 shall be used.

d) Rigid and flexible metallic conduits, metallic bunking and ducting and metallic screens and armouring which meet the requirements of 54-3.2.1of Chapter 54.

Each conductor specified in Items a), b), c) and d) shall meet the other requirements of 54-3 of Chapter 54.

707:41-0.3.3.2 Earth continuity monitoring

NOTE The aim of these requirements is to monitor the continuity of the protective earth connection and provide means of automatic supply disconnection in case of failure.

A device or devices shall be provided which will disconnect the equipment in the event of a discontinuity occurring in the protective conductor in accordance with the requirements of 41-3.1 of Chapter 41.

The protective conductor shall comply with 54-3 of Chapter 54.

707:41-0.3.3.3 Use of double wound transformer

NOTE The aim of these requirements is to localize the path of the leakage current and minimize the possibility of a break in continuity in this path.

Where equipment is connected to the supply via a double wound transformer or other units in which the input and output circuits are separated, such as motor-alternator sets, the secondary circuit should preferably be connected as TN-system but an IT-system may be used where required for specific applications.

The earth connections between the equipment and the transformer shall comply with the requirements of 707:41-0.3.3.1 or 707:41-0.3.3.2.

707:41-0.4 Additional requirements for TT-system

707.41-0.4.1 Where the circuit is protected by a residual current protective device, the total leakage current I_1 (in amperes), the resistance of the earth electrode R_A (in ohms) and the rated operating residual current of the protective device $I_{\Delta n}$ (in amperes) shall be related as follows:

$$I_l \leq \frac{I_{\Delta n}}{2} \leq \frac{U_L}{2R_A}$$ (Where U_L is the conventional touch voltage limit)

707:41-0.4.2 If the requirement of 707:41-0.4.1 cannot be met, the requirements of 707:41-0.3.3.3 shall apply.

707:41-0.5 Additional requirements for IT systems

707:41-0.5.1 It is preferred that equipment with high-leakage current is not connected directly to IT systems because of the difficulty of satisfying touch voltage requirements after a first fault.

Where possible, the equipment should be supplied by a TN-system derived from the IT-mains supply by means of a double wound transformer.

Where it is possible to comply with 41-3.1.5.3 of Chapter 41, the equipment may be connected directly to the IT system. This may be facilitated by connecting all protective earth connections directly to the power system earth electrode.

707:41-0.5.2 Before making direct connection to an IT system, installers shall ensure that equipment is suitable for connection to IT systems in accordance with the declaration of the manufacturer.

707:54 Earthing arrangements, protective conductors and protective bonding conductors

707:54-5.2 Safety requirement for low noise earthing arrangements

NOTE It may be found that the electrical noise levels on the protective earthing system of building installations cause an unacceptable incidence of malfunction on data processing equipment connected to it.

707:54-5.2.1 Exposed conductive parts of data processing equipment shall be connected to the main earthing terminal.

NOTE 41-3.1 of Chapter 41 forbids the use of separate earth electrodes for simultaneously accessible exposed conductive parts.

This requirement shall also apply to metallic enclosures of Class II and Class III equipment and to FELV circuits when these are earthed for functional reasons.

Earth conductors which serve functional purposes only need not comply with 54-3 of Chapter 54.

707:54-5.2.2 Other special methods

In extreme cases, if the safety requirements of 707:54-5.2.1 are fulfilled but electrical noise on the main earthing terminal of the installation cannot be reduced to an acceptable level, the installation has to be treated as a special case.

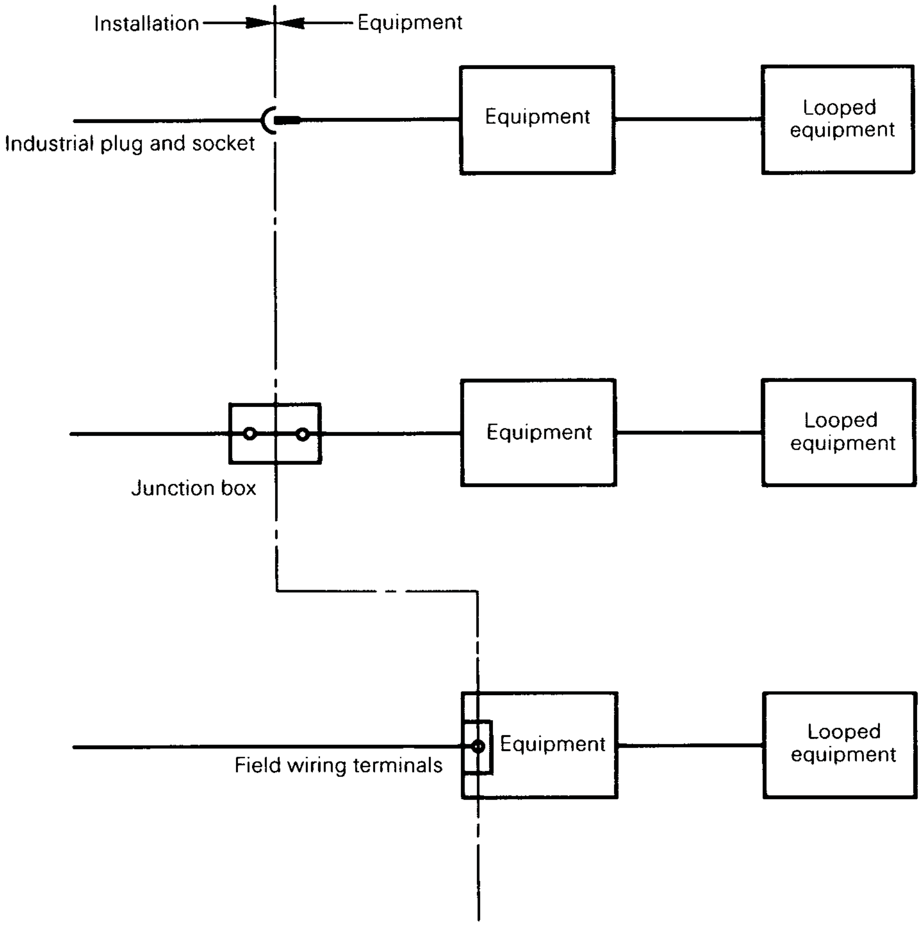
The earthing arrangement has to provide the same level of protection as is generally provided by this standard and particular attention should be given to ensuring that the arrangement:

- provides adequate protection against overcurrent;

- prevents excessive touch voltages on the equipment and ensures equipotential between the equipment and adjacent metal work or other electrical equipment, under normal and fault conditions;
- meets the requirements relating to excessive earth leakage current, if appropriate, and does not invalidate them.

Annex A.707
(informative)

Equipment and Installations



NOTE Looped equipment is equipment supplied via another item of equipment.

Figure A.707-1 Equipment-installation boundaries

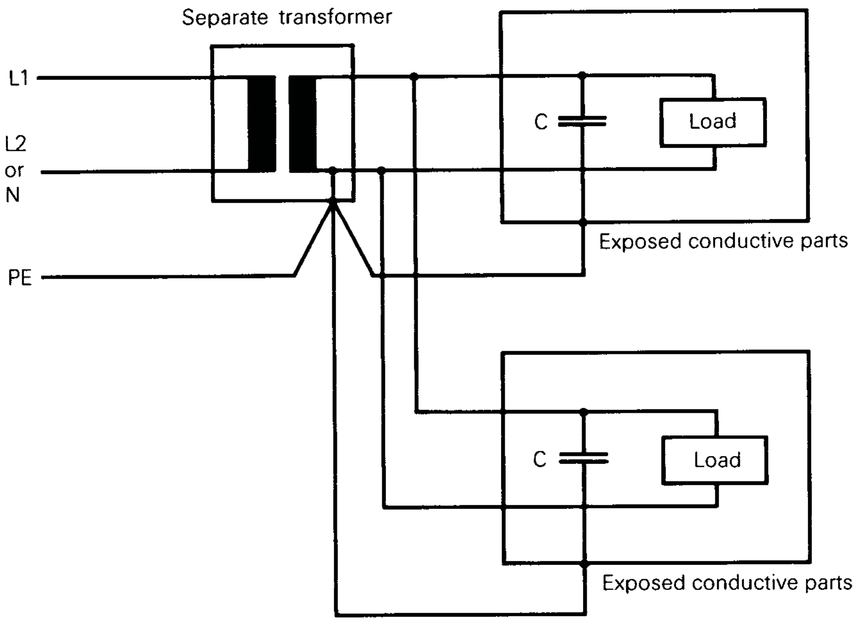


Figure A.707-2 Method of connecting transformers with separate windings.

Single-phase system depicted for ease. System may be three-phase.

The means of control and protection of primary and secondary circuits are not shown.

C is the filter capacitance.

L1 and L2 or N are connections to the incoming supply and PE is the connection from accessible parts of the equipment to the main earthing terminal of the installation for both protective conductors of Class I equipment and functional earthing conductors of Class II equipment.

CHAPTER 708
ELECTRICAL INSTALLATIONS IN CAMPING SITES, CARAVANS AND TENTS

708:11 Scope

The particular requirements of this chapter apply to that portion of the electrical installation in camping sites (e.g., caravan and tent parks) providing facilities for connection of leisure accommodation vehicles (including caravans) or tents, and to the internal electrical installations in caravans, motor caravans and tents for rated voltages not exceeding 400 V.

Requirements for caravans are applicable for motor caravans.

The particular requirements of this chapter do not apply to the internal electrical installations of leisure homes and mobile homes, fixed recreational vehicles, transportable sheds and the like, temporary premises or structures.

708:41 Protection against electric shock

708:41-2 Protection against direct contact

708:41-2.3 Protection by obstacles

Protection by obstacles shall not be used.

708:41-2.4 Protection by placing out of reach

Protection by placing out of reach shall not be used.

708:41-3 Protection against indirect contact

708:41-3.1 Protection by automatic disconnection of supply

708:41-3.1.1 TN system

Where the type of system earthing is TN, the installation shall be TN-S.

708:41-3.1.2 Protection by automatic disconnection of supply in caravans

Where protection by automatic disconnection of supply is used a residual current device complying with 41-2.5.3 of Chapter 41 breaking all live conductors shall be provided.

The wiring system shall incorporate a protective conductor connected to the protective contact of the caravan inlet, which shall be connected also to exposed conductive parts of electrical equipment and to the protective contact of the socket-outlets in the caravan.

708:41-3.1.3 Protection by automatic disconnection of supply in tents

Where protection by automatic disconnection of supply is used a residual current device complying with 41-2.5.3 of Chapter 41 breaking all live conductors shall be provided.

The wiring system shall incorporate a protective conductor connected to the protective contact of the socket-outlets in the tent.

708:41-3.1.6 Supplemetary equipotential bonding

708:41-3.1.6.1 Supplemetary equipotential bonding in caravans

Extraneous conductive parts of the caravan shall be bonded to the protective conductor of the installation, if necessary in more than one place if the type of construction does not ensure continuity. The nominal cross-sectional area of conductors used for this purpose shall be not less than 4 mm^2 copper.

If the caravan is made substantially of insulating material, these requirements do not apply to metal parts which are unlikely to become live in the event of a fault.

708:41-3.1.6.2 Supplemetary equipotential bonding in tents

Extraneous conductive parts of the tent shall be bonded to the protective conductor of the installation, if necessary in more than one place if the type of construction does not ensure continuity. The nominal cross-sectional area of conductors used for this purpose shall be not less than 4 mm^2 copper.

708:41-3.3 Non-conducting location

Protection by non-conducting location shall not be used.

NOTE This precludes the use of Class 0 equipment.

708:41-3.4 Earth-free local equipotential bonding

Protection by earth-free local equipotential bonding shall not be used.

708:42 Protection against thermal effects

708:42-2 Measures for protection against fire

708:42-2.3.10 Automatic disconnection of supply to camping sites shall be protected at the origin of the installation by a residual current protective device, the rated operating residual current of which does not exceed 0.5 A.

NOTE This is necessary to limit the consequences of fault currents in wiring systems from the point of view of fire risks.

708:52 Wiring systems

708:52-1 Types of Wiring systems

708:52-1.1 Method of supply in camping sites

NOTE The preferred method of supply to leisure accommodation vehicles or tents is by means of underground distribution circuits feeding caravan pitch supply equipment.

708:52-1.1.1 Underground distribution circuits

Underground wiring systems shall, unless provided with additional mechanical protection, be placed outside any caravan pitch or outside any area where tent pegs or earth anchors may be driven.

708:52-1.1.2 Overhead distribution circuits

- All overhead conductors shall be insulated conductors in accordance with 41-2.1 of Chapter 41 and shall be located at a minimum of 2 m outside the vertical surface extending from the horizontal boundary of any caravan pitch.
- Poles and other supports for overhead wiring shall be located or protected so that they are unlikely to be damaged by any vehicle movement foreseen.
- Overhead conductors shall be at a height above earth not less than 6 m in all areas subject to vehicle movement and 3.5 m in all other areas.

708:52-1.2 Wiring systems in caravans and tents

708:52-1.2.1 Arrangement

The wiring may be arranged in one or more electrically independent systems. Each independent system shall be supplied by a separate connecting device.

708:52-1.2.2 Cables and conduits

The following types of cables shall be used:

- flexible single-core cables (227 IEC 02) in non-metallic conduits;

- rigid stranded cables with a minimum of 7 strands (227 IEC 01) in non-metallic conduits;
- ordinary polychloroprene sheathed flexible cables (245 IEC 57) or equivalents.
- conduits shall comply with SASO 254 and SASO 255. The pliable polyethylene type shall not be used.

708:52-1.2.3 Cross-sectional area

The cross-sectional area of conductors shall be appropriate to the load to be connected within the caravan or tent and in any case shall not be smaller than 1.5 mm^2.

NOTE Attention is drawn to the effect of thermal insulation on the current-carrying capacity of cables. This may necessitate the use of larger cables.

708:52-1.2.4 Single-core protective conductors

Single-core protective conductors shall be insulated. The nominal cross-sectional area of conductors used for this purpose shall be not less than 4 mm^2 copper.

708:52-1.2.5 Mechanical protection

All wiring shall be protected against mechanical damage either by location or by additional protection. Wiring passing through metal work shall be protected by means of suitable bushes or grummets, securely fixed in position. Every precaution shall be taken to avoid mechanical damage due to sharp edges or abrasive parts.

708:52-1.2.6 Segregation

Cables operating at low-voltage shall be run separately from cables for extra-low-voltage and shall be so disposed that there is no risk of physical contact between the two wiring systems.

708:52-1.2.7 Routing

708.52-1.2.7.1 Unless routed in conduits, all cables shall be supported with insulated clips at intervals not exceeding 0.4 m for vertical runs and at intervals not exceeding 0.25 m for horizontal runs.

Cables runs, if inaccessible, shall be unbroken.

708:52-1.2.7.2 Cable connections and joints shall be made in purpose-designed boxes providing mechanical protection. If the cover of the box is removable without the aid of a tool, the connections shall be insulated.

Cable conduits and connection boxes shall be of material in accordance with SASO IEC 60695-2-10 (see 708:53-0.4.2.1), unless; other values are specified in the relevant equipment specification .

708:52-1.2.7.3 No wiring shall be located within or pass through a compartment intended for gas cylinders.

708:52-1.3 Particular requirements for connecting devices (see Figure 708-1)

The means of connection between the caravan pitch socket-outlet and the leisure accommodation vehicle or the tent shall be an assembly of the following:

- a plug with protective contact as specified in SASO IEC 60309-2;
- a flexible cord type 245 IEC 66 or equivalent, with a protective conductor and having the following characteristics:

  length: 25 m (± 2m). Cross-sectional area:

For rated currents not exceeding	16 A:	2.5 mm^2
For rated currents not exceeding	25 A:	4 mm^2
For rated currents not exceeding	32 A:	6 mm^2
For rated currents not exceeding	63 A:	16 mm^2
For rated currents not exceeding	100 A:	35 mm^2

NOTE External influences shall be considered
Colour identification:
Protective conductor: bicolour green and yellow
Neutral conductor: blue

- a connector as specified in SASO 1693.

708:53 Isolation switching and control

708:53-0.4 Switchgear and controlgear for caravan pitch

708:53-0.4.1 Caravan pitch supply equipment

Caravan pitch supply equipment shall be located adjacent to the pitch and not more than 20 m from the connection facility on the leisure accommodation vehicle or tent when on its pitch.

708:53-0.4.2 Caravan pitch Socket-outlets

708:53-0.4.2.1 Socket-outlets to supply power to a leisure accommodation vehicle shall be one of the configurations selected from SASO IEC 60309-2. They shall be located in enclosures made of material complying with SASO IEC 60695-2-11 (850°C for parts supporting current-carrying parts and 650°C for enclosures), unless other values are specified in the relevant Saudi equipment standards.

708:53-0.4.2.2 The socket-outlets shall be placed at a height of 0.80 m to 1.50 m from the earth to the lowest part of the socket-outlet.

708:53-0.4.2.3 The current rating of socket-outlets shall be not less than 16 A. Outlets of higher current ratings shall be provided where greater demands are envisaged.

708:53-0.4.2.4 At least one socket-outlet shall be provided for the connection of each leisure accommodation vehicle or tent. Grouped single-phase socket-outlets shall be on the same phase.

708:53-0.4.2.5 Each socket-outlet shall be provided with individual overcurrent protection.

708:53-0.4.2.6 Socket-outlets shall be protected by a residual current protective device with a rated residual operating current not exceeding 30 mA. One residual current protective device shall protect not more than three socket-outlets.

NOTE It is recommended that a warning notice be provided at the caravan pitch supply equipment location to warn all users that a fault in one circuit can disconnect that supply to the other socket-outlets.

708:53-0.5 Switchgear and controlgear for caravan and tent

708:53-0.5.1 Electrical inlet

708:53-0.5.1.1 The electrical inlet shall be an appliance inlet as specified in SASO IEC 60309-2, suitable for accepting the type of connector provided on the connecting device and shall incorporate a protective contact.

708:53-0.5.1.2 The inlet shall be installed:

- as high as practicable but not more than 1.8 m above earth level;
- in a readily accessible location; and
- in a suitable recess incorporating a lid on the outside of the caravan.

708:53-0.5.1.3 A notice of such durable material as to be likely to remain legible throughout the life of the installation shall be fixed on or rear the electrical inlet recess where it can be easily read and shall bear the following information (in Arabic and English):

- the nominal voltage and frequency for which the caravan installation has been designed.
- the rated current of the caravan installation.

NOTE This requirement is not applicable for tent.

708:53-0.5.2 Main switch

Every internal electrical installation shall be equipped with a main control switch which disconnects all live conductors (including the neutral if any) placed in a readily accessible position inside the caravan.

A warning notice of durable material shall be permanently fixed in a prominent position in the vicinity of the main switch. This notice shall be in arabic and english, and shall contain at least the following information:

- connecting/disconnecting procedure on arriving at, or leaving a site;
- warning: supply flexible cable must be fully uncoiled to avoid damage by overheating;
- warning: not more than one flexible cable or cord shall be connected to a plug;
- warning: multi-way plug-in type adapters shall not be used;
- procedure in the event of a fault;
- fuse replacement procedure (if any);
- recommendation for periodic inspection.

708:53-0.5.3 Protection of circuits against overcurrent

Every final circuit shall be protected against overcurrents by an individual overcurrent protective device which disconnects all live conductors. This statement does not apply to installations which contain only one final circuit with a current rating not exceeding 16 A.

NOTE If there is only one final circuit, the overcurrent protective device required by this statement may also serve as the main control switch required by 708:53-0.5.2.

708:53-0.5.4 Accessories

708:53-0.5.4.1 General

Accessories such as socket-outlets, switches, lampholders and the like shall be of a type without accessible metallic parts.

708:53-0.5.4.2 Socket-outlets

Low-voltage socket-outlets shall incorporate a terminal for connection of the protective conductor. This requirement does not apply to socket-outlets supplied by an individual isolating transformer.

Where extra-low-voltage (ELV) socket-outlets are provided in the caravan, all socket-outlets of the low-voltage installation shall be of a type which will not admit plugs intended for the ELV socket-outlets.

708:53-0.5.4.3 Exposure to weather

Where a socket-outlet or other accessory is located in a position exposed to the effects of moisture, it shall be constructed or enclosed so as to provide a degree of protection not less than IP 55.

708:53-0.6 Extra-low-voltage installations

708:53-0.6.1 General

Any portion of a caravan installation operating at extra-low-voltage shall comply with the requirements of 41-1.1 of Chapter 41. the sources for SELV and PELV that are listed in 41-1.1.2 of Chapter 41 are permissible.

The following standard voltages as specified in SASO 182 shall be selected:

A.C. or D.C. 12 V, 24 V or 48 V.

708:53-0.6.2 Socket-outlets

All socket-outlets supplied at extra-low-voltage shall have their voltage conspicuously marked and shall be of a form to prevent the insertion of a low-voltage plug.

708:53-0.7 Electrical installations in compartments containing a bath or shower

708:53-0.7.1 Attention is drawn to the following requirements of Chapter 701:

- equipotential bonding shall be provided between simultaneously accessible exposed conductive parts, between exposed conductive parts and simultaneously accessible extraneous conductive parts, and between simultaneously accessible extraneous conductive parts;
- switches shall be situated so as to be inaccessible to a person using the bath or shower. This requirement does not apply to electric shaver supply units or to insulating cords of cord operated switches;
- socket-outlets shall not be installed, except for a socket-outlet with isolating transformer as a complete unit, of Class I or II construction;
- luminaires shall be of Class II construction.

708:53-0.7.2 Modification to 701:51-2.2

The space defined by the surface area occupied by a bath or shower basin, projected from floor to ceiling, shall contain no electric appliances, luminaires or other item of electrical equipment, with the exception of an electric water-heater, which shall at least be of splash-proof construction (IPX4).

708:55 Other equipment

708:55-8 Appliances

Every appliance which is permanently connected to the fixed wiring shall be controlled by a switch installed on or adjacent to the appliance, unless the appliance is provided with an incorporated switch.

708:55-9 Luminaires

708:55-9.1 Luminaires should preferably be fixed directly to the structures or Iining of the caravan.

708:55-9.2 Where pendant luminaires are installed, provision shall be made for securing the luminaire to prevent damage to the flexible cord or luminaire when the caravan is moved. Accessories associated with pendant luminaires shall be suitable for the mass suspended.

708:55-9.3 Luminaires intended for dual voltage operation shall:

- be fitted with separate lampholders for each voltage;
- have an indication of the lamp wattage and voltage clearly and permanently displayed near each lampholder;
- be so designed that no damage will be caused if both lamps are illuminated at the same time;
- be so designed that there is no possibility of contact between LV and ELV circuits;
- have LV and ELV terminals so disposed as to permit satisfactory separation of LV and ELV wiring;
- be so designed that lamps cannot be inserted in lampholders intended for lamps of other voltages.

708:55-9.4 Luminaires mounted below 2.5 m (arm's reach) from floor level or otherwise accessible to accidental contact shall be firmly and adequately fixed, and so sited or guarded as to prevent risk of injury to persons or ignition of materials.

708:55-9.5 Insulation piercing lampholders shall not be used unless the cables and lampholders are compatible, provided that the lampholders are non-removable once fitted to the cable.

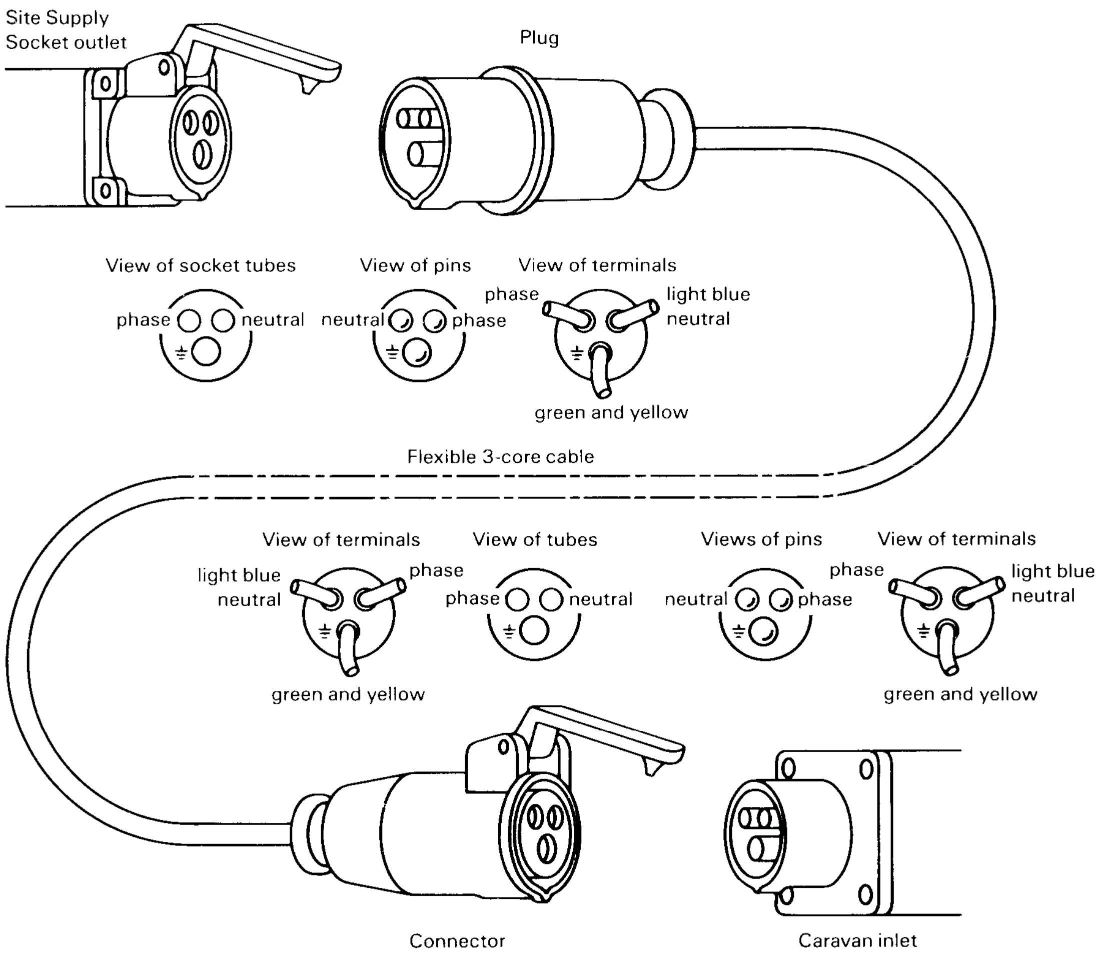


Figure 708-1 Example of a 2P+E supply system

CHAPTER 709
MARINAS AND PLEASURE CRAFT

709:11 Scope

The particular requirements of this chapter apply to:

- the electrical installation in marinas which provide connections to pleasure craft; and to
- the electrical installation in pleasure craft supplied only from the on-shore power-supply system.

NOTE Such installations are characterized by the risk of corrosion, movement of structures, mechanical damage and the risk of electric shock being increased by reduction in body resistance and contact of the body with earth potential.

709:31 Purposes, supplies and structure

709:31-0 General requirements

Electrical power installations of pleasure craft and the associated power-supply system located at marinas shall be installed and the equipment so selected as to minimize the risk of electric shock, fire and explosion.

709:31-3 Nominal supply systems

The nominal supply voltage of the installation to pleasure craft shall not exceed 230 V single-phase.

709:32 External influences

Equipment installed on or above the deck of pleasure craft shall comply with the degree of protection IP55, in accordance with SASO 1980, unless equivalent protection is provided by other means.

709:41 Protection against electric shock

709:41-2 Protection against direct contact

709:41-2.3 Protection by obstacles

Protection by obstacles shall not be used.

709:41-2.4 Protection by placing out of reach

Protection by placing out of reach shall not be used.

709:41-3 Protection against indirect contact

709:41-3.1 Protection by automatic disconnection of supply

709:41-3.1.3 Use of a TN system in marinas

In the case of a TN system, only a TN-S system shall be used. Residual current protective devices shall be used except where protection is provided by an onshore isolating transformer (see 709:41-3.5.1).

709:41-3.1.6 Supplementary bonding for pleasure craft

With the exception of the case referred to in 709:41-3.5.1.3 (see Annex A.709, Figure A.709-4), accessible conductive parts of the pleasure craft that are likely to attain fault voltage or earth potential, shall be connected to each other through an equipotential bonding conductor, and to the protective conductor.

The equipotential bonding conductor shall have a cross-sectional area of at

least 4 mm² copper and shall be flexible (regarding the cross-sectional area, see 54-7.1.2 of Chapter 54).

This does not apply to metal parts that are insulated to prevent direct contact, for example, by basic insulation.

709:41-3.3 **Protection by non-conducting location**

Protection by a non-conducting location shall not be used.

NOTE This precludes the use of class 0 equipment.

709:41-3.5 **Protection by electrical separation**

Isolating transformers in accordance with SASO IEC 61558 shall be used.

NOTE For examples of the use of RCDs in conjunction with on-board isolating transformers see Annex A.709, Figures A.709-3 and A.709-4.

709:41-3.5.1 **Isolating transformers**

a) Connection to shore supply through an on-shore isolating transformer.

NOTE See Annex A.709 Figure A.709-2.

The isolating transformer shall comply with SASO IEC 61558.

No connection of the bonding of the pleasure craft with the protective conductor of the shore supply shall be made and only one pleasure craft shall be connected to each secondary winding of an isolating transformer.

The following items shall be effectively connected to a bonding conductor, which, in turn, shall be connected to one of the secondary winding terminals of the isolating transformers:

- Metal parts of the pleasure craft in electrical contact with the water, more than one connection point being required if the type of construction does not ensure continuity;

  NOTE The above requirements do not apply to metal parts mounted on insulating material or which are insulated from other metal parts.
- The protective contact of each socket-outlet;
- The exposed conductive parts of equipment.

b) Connection to shore supply through an on-board isolating transformer with bonding.

NOTE See Annex A.709 Figure A.709-3.

The isolating transformer shall comply with the appropriate requirements of Chapter 41, 41-3.5 and SASO IEC 61558. No connection of any bonding on the pleasure craft shall be made with the protective conductor of the shore supply.

When the secondary winding of the isolating transformer is to be bonded to metal parts of the pleasure craft (see Annex A.709, Figure A.709-3), the following items shall be effectively connected to a bonding conductor which, in turn, shall be connected to one of the secondary winding terminals of the isolating transformer:

- The protective contact of each socket-outlet;
- The exposed conductive parts of equipment on the pleasure craft;
- Metal parts in electrical contact with water surrounding the pleasure craft.

c) Connection to shore supply through an on-board isolating transformer with no bonding.

NOTE See Annex A.709, Figure A.709-4.

The isolating transformer shall comply with appropriate requirements of Chapter 41, 41-3.5 and SASO IEC 61558.

When the secondary winding of the isolating transformer is not to be bonded to metal parts of the pleasure craft (see Annex A.709, Figure A.709-4), only one socket-outlet or appliance shall be connected to each secondary winding.

NOTE Transformers may have more than one secondary winding.

709:52 Selection and erection of wiring systems

709:52-0.1 Wiring systems of marinas

709:52-0.1.1 The following wiring systems are suitable for marinas:

a) Cables with copper conductors and thermoplastic or elastomeric insulation and sheath installed within:
- Flexible non-metallic conduit, or
- Heavy or heavy-duty galvanized conduit;

b) Mineral-insulated cables with PVC protective covering;

c) Cables with armouring and serving of thermoplastic or elastomeric material;

d) Other cables and materials that are no less suitable than those listed under a), b) or c) above.

709:52-0.1.2 The following wiring systems shall not be used on floating installations or jetty structures:
- Overhead lines;
- Cables which may become tight;
- Cables with aluminium conductors.

709:52-0.1.3 Conduit installations shall have suitable apertures or holes to allow for the drainage of any moisture.

709:52-0.2 Wiring systems of pleasure craft

709:52-0.2.1 With the exception of the case referred to in 709:41-3.5.1 c (see Annex A.709, Figure A.709-4), a protective conductor shall be incorporated in each circuit.

709:52-0.2.2 Cables shall be so installed that mechanical damage due to craft movements is prevented.

Cables are to be installed in such a manner that they are prevented from:
- being displaced by movements of the pleasure craft, or
- being damaged due to friction, tension or crushing,
- and being exposed to inadmissible ambient temperatures.

Except where cables are installed in plastic conduits, cable ducts, structural voids and the like, they shall be fixed by means of non-corroding clips or straps at distances of approximately 30 cm. They shall be laid at a safe distance from fuel tanks, exhaust gas pipes and heat sources.

709:52-0.2.3 The following types of cables with a minimum cross-sectional area of 1.5 mm² shall be used:
- Flexible single-core cables (227 IEC 02) in non-metallic conduit;
- Rigid stranded cables with a minimum of seven strands (227 IEC 01) in non-metallic conduit;
- Ordinary polychloroprene-sheathed flexible cable (245 IEC 57) or equivalent.
- Conduits shall comply with SASO IEC 60614. The pliable polyethylene type shall not be used.

709:52-0.2.4 There shall be no inaccessible cable connections.

709:52-0.2.5 Cable connections shall be by means of connector sleeves (ferrules) using terminals, screwed joints or crimped connections all corrosion proof type.

Screwed joints shall be with a means of self-locking.

Cable connections shall be located in suitable boxes providing adequate protection. The covers shall be removable only with the aid of a tool.

709:52-0.2.6 Bushings for cables or cords passing through decks or bulkheads shall be of waterproof construction.

709:52-0.2.7 For cable routing in the proximity of circuits at extra-low-voltage (ELV), see 41-1.1.3.4 of Chapter 41.

709:53 Isolation, switching and control

709:53-0.1 Distribution boards and socket-outlets of marinas

709:53-0.1.1 Distribution boards supplying marinas shall be arranged in the immediate vicinity of the berths and shall be located as close as possible to the berth to be supplied.

709:53-0.1.2 Distribution boards mounted outdoors shall meet the degree of protection IP24 in accordance with SASO 980. The enclosure shall be corrosion-resistant and give protection against mechanical damage.

When distribution boards and their associated socket-outlets are mounted on floating installations or jetties, they shall be fixed not less than 1 m above the walkway. This distance may be reduced to not less than 300 mm if appropriate additional measures against splashing are taken.

709:53-0.1.3 Distribution boards supplying marinas shall provide one socket-outlet for each berth. Socket-outlets shall be in accordance with SASO IEC 60309-2 and each outlet shall be connected to the protective conductor and have the following characteristics irrespective of the measure of protection against electric shock:

- Rated voltage: 250 V
- Rated current: 16 A
- Clock position: 6 h
- Number of poles: 2 plus protective conductor
- Construction: IPX4

709:53-0.1.4 Up to six socket-outlets may be grouped together in one enclosure. Socket-outlets or groups of socket-outlets intended for use on the same walkway or jetty shall be connected to the same phase unless fed from isolating transformers.

NOTE See Annexes C.709 and D.709 regarding recommended notices to be placed adjacent to each group of socket-outlets.

709:53-0.1.5 Each group of socket-outlets shall be protected by an RCD having a rated residual operating current not exceeding 30 mA (see Annex A.709, Figure A.709-1), or each socket-outlet shall be protected by an isolating transformer (see Annex A.709, Figure A.709-2) or by a system comprising both the RCD and an isolating transformer (see annex A.709, figure A.709-3 and A.709-4).

709:53-0.1.6 Each socket-outlet shall be provided with an individual overcurrent protective device having a maximum rated current of 16 A. Depending on the supply characteristics, double-pole protection may be required (see 44-3 of Chapter 4).

709:53-0.2 Connection to pleasure craft

709:53-0.2.1 Components of the connecting device

The connecting device of pleasure craft is composed of:

a) A plug with a contact connected to the protective conductor having the characteristics as given in 709:53-0.1.3;

b) A three-core flexible cable, type 245 IEC 65 or equivalent, which is either permanently connected in the pleasure craft, or can be connected by a connector having the characteristic as given in 709:53-0.1.3 (see Annex B.709, Figure B.709-1).

709:53-0.2.2 Cable length

The cable length should not exceed 25 m. The cable shall not have any intermediate connections throughout its length.

709:53-0.2.3 Appliance inlet

When connection to the craft is made by means of an appliance inlet and connector, these shall be in accordance with 709:53-0.1.3 and mounted at a readily accessible point.

The appliance inlet shall be located at a point where the inlet itself, including the connecting cable cannot be damaged by the movements of the craft, abrasion by touching the anchor wires, mooring hawsers (lines), squashing or abrasion of other movable parts, including any auxiliary dinghy.

709:53-0.2.4 Changeover interlock

When changing over from the onshore low-voltage power-supply system to the low-voltage power-supply system on board the craft and vice versa, parallel connection of the supplies shall not be possible.

709:53-0.3 Distribution boards of pleasure craft

709:53-0.3.1 All circuits shall be terminated within distribution boards which comply with 709:53-0.1 and 709:53-0.2.

Distribution boards, switchboards, switchgear and controlgear shall be readily accessible. Distribution board and switchboard enclosures shall be made of metal or a material that is flame-retardant and self-extinguishing (see SASO IEC 60695-2-10).

709:53-0.3.2 Each final circuit shall be protected by an overcurrent protective device in the form of a circuit-breaker or fuse having an appropriate rating.

709:53-7 Devices for isolation and switching

709:53-7.1 Main switch

Pleasure craft shall be provided with a switch to isolate all circuits, which shall be located at a readily accessible point. Should only one circuit be present, the overcurrent protective device shall suffice to provide for isolation.

Annex A.709
(normative)

Methods of Obtaining Low-Voltage Supply

Note to Figures A.709-1 to A.709-4 - Normal off/on switches are not shown.

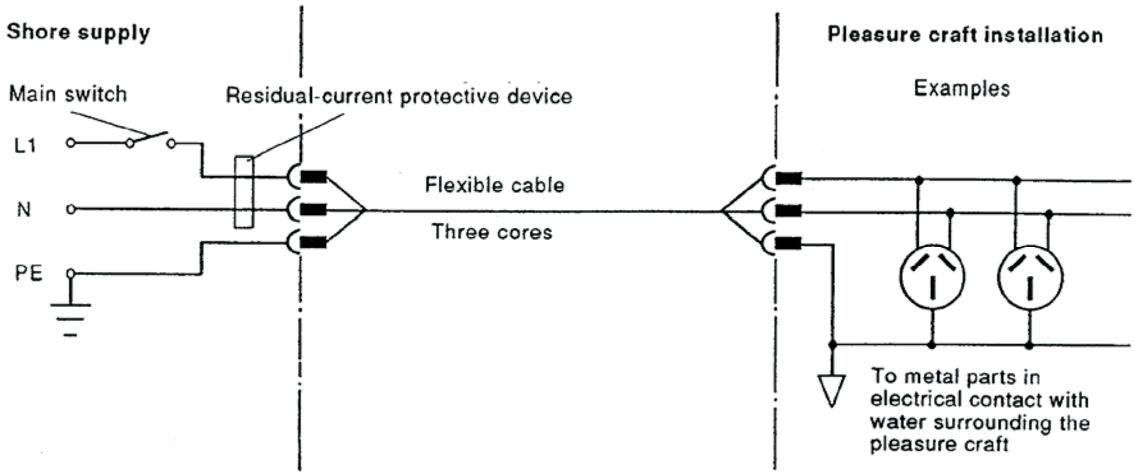


Figure A.709-1 Direct connection to mains supply with residual-current protective device

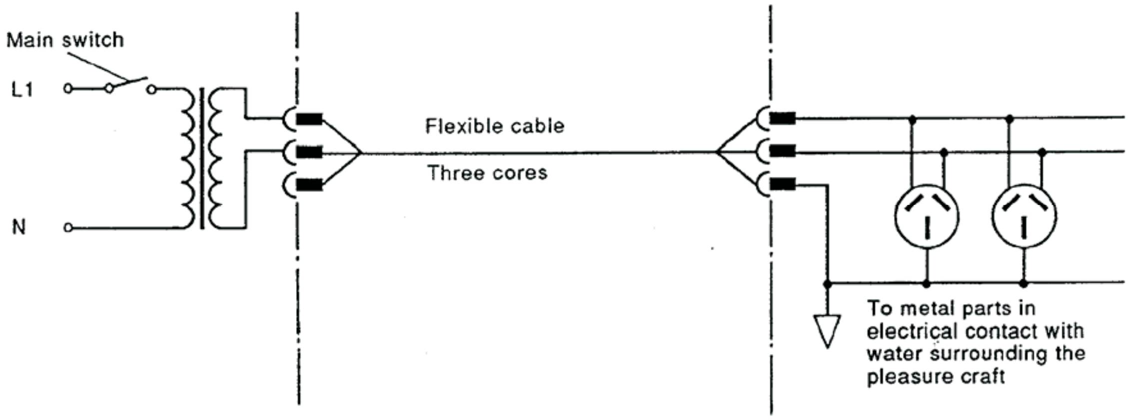


Figure A.709-2 On-shore-mounted isolating transformer. Connection to mains supply through shore-mounted isolating transformer (hull and metal parts bonded)

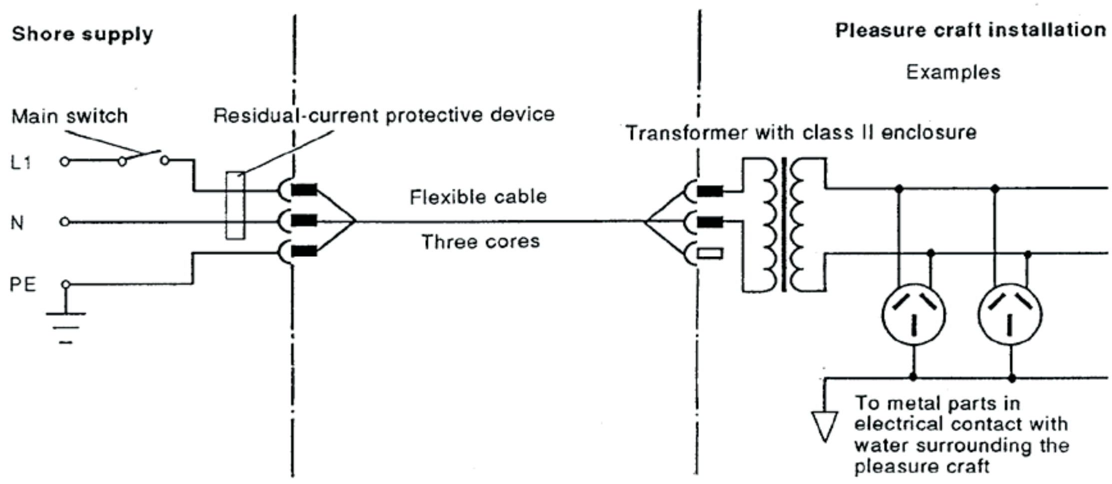
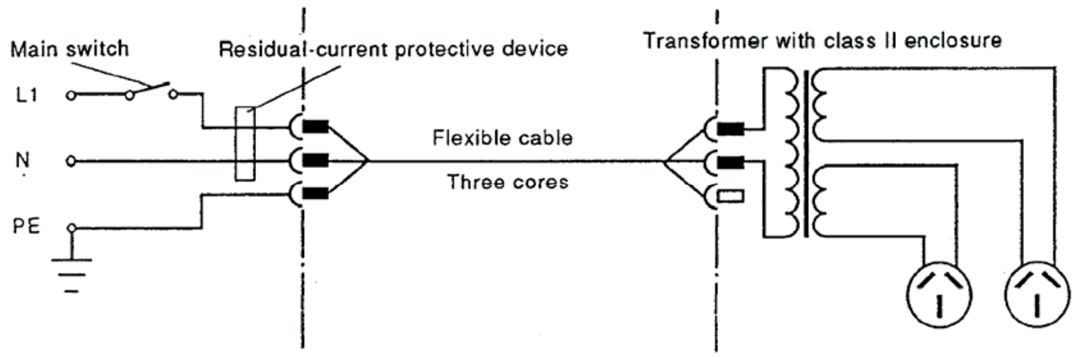


Figure A.709-3 On-board isolating transformer. Connection to mains supply with residual-current protective device through on-board isolating transformer (hull and metal parts bonded)



NOTE Only one socket-outlet, or one appliance per output winding [see 709.41-3.5.1 c)].

Figure A.709-4 Connection to mains supply with residual-current protective device through on-board isolating transformer (no bonding)

Annex B.709
(normative)

Connection between Marina and Pleasure Craft

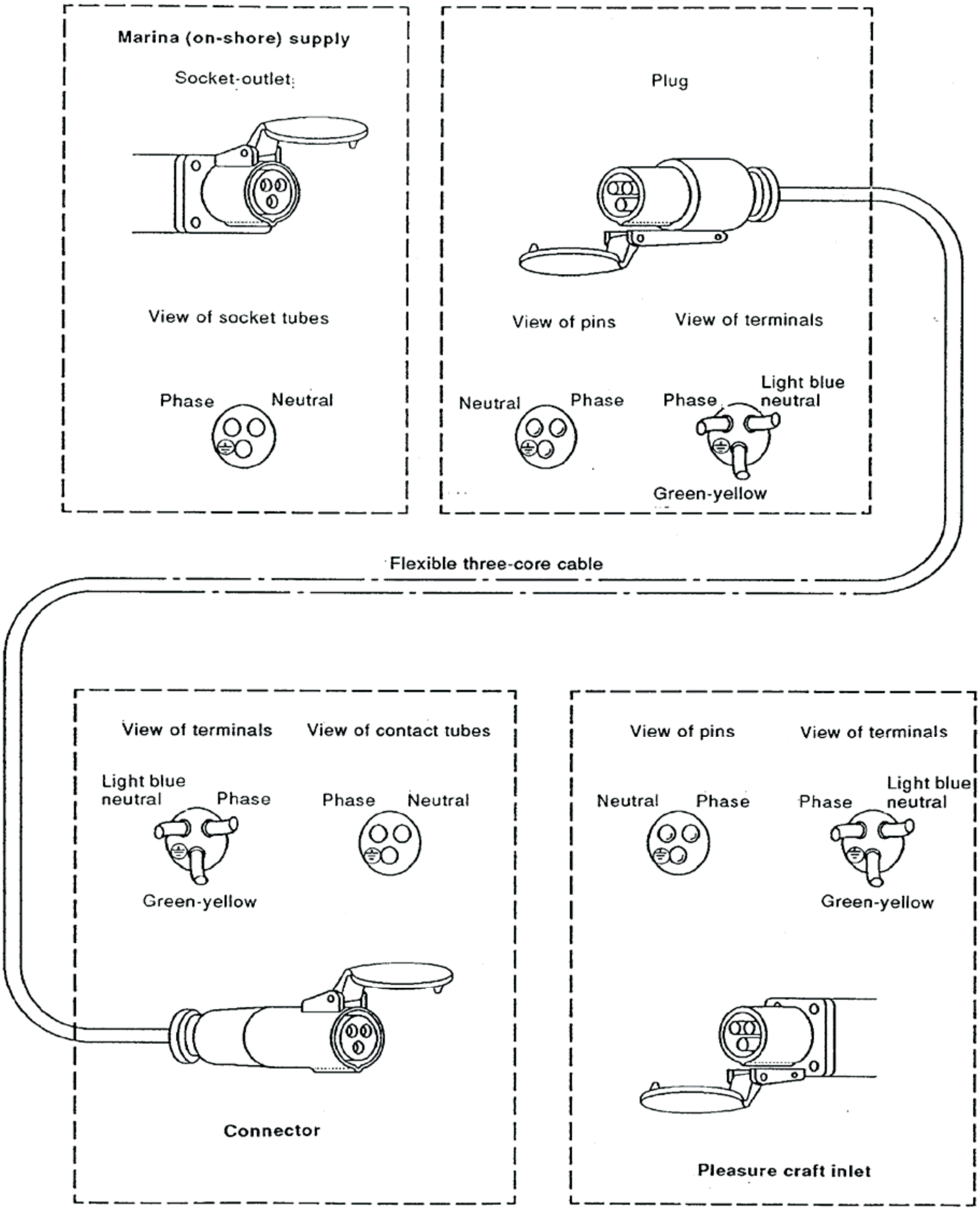


Figure B.709-1 Example of a two-pole and protective conductor supply system

CHAPTER 710
MEDICAL LOCATIONS

710:11 Scope

The particular requirements of this chapter apply to electrical installations in medical locations so as to ensure safety of patients and medical staff. These requirements, in the main, refer to hospitals, private clinics, medical and dental practices, health care centers and dedicated medical rooms in the work place.

NOTE 1 It may be necessary to modify the existing electrical installation, in accordance with this chapter, when a change of utilization of the location occurs. Special care should be taken where intracardiac procedures are performed in existing installations.

NOTE 2 Doctors offices within an office building or a Doctor's business office would be treated as an ordinary occupancy and would be required to meet only the applicable portions of other parts of these Electrical Requirements. However the examining rooms attached to to the Doctor's business office would be required to meet the provisions of this chapter.

NOTE 3 The requirements of this chapter apply also to the health care facilities that may be be mobile orsupply very limited outpatient services. However the scope does not include animal hospitals or veterinary offices.

NOTE 4 For medical electrical equipment, refer to SASO IEC 60601 series.

The classification of a medical location shall be made in agreement with the medical staff, health organization concerned or body responsible for the safety of workers in accordance with national regulations. In order to determine the classification of a medical location, it is necessary that the medical staff indicate which medical procedures will take place within the location. Based on the intended use, the appropriate classification for the location shall be determined (the possibility that certain medical locations may be used for different purposes which necessitate a higher group should be addressed by risk management).

NOTE 1 Classification of a medical location should be related to the type of contact between applied parts and the patient, as well as the purpose for which the location is used (see Annex B.710).

NOTE 2 Applied parts are defined by the particular standards for medical electrical equipment.

710:31 Purposes, supplies and structure

710:31-2.2 Types of system earthing

The TN-C system is not allowed in medical locations and medical buildings downstream of the main distribution board.

710:31-3 Power supply

710:31-3.1 General

In medical locations the distribution system should be designed and installed to facilitate the automatic change-over from the main distribution network to the electrical safety source feeding essential loads (according to 55-6 of Chapter 55).

710:41 Protection against electric shock

710:41-1 Protection against both direct and indirect contact

710:41-1.1 SELV and PELV

When using SELV and/or PELV circuits in medical locations of group 1 and group 2, the nominal voltage applied to current-using equipment shall not exceed 25 V a.c. or 60 V d.c. Protection by insulation of live

parts according to 41-2.1 of chapter 41 and by barriers or enclosures according to 41-2.2 of Chapter 41 is essential.

In medical locations of group 2, exposed-conductive-parts of equipment (e.g. operating theatre luminaires), shall be connected to the equipotential bonding conductor.

710:41-2 Protection against direct contact

710:41-2.3 Obstacles

Protection by obstacles is not permitted.

710:41-2.4 Placing out of reach

Protection by placing out of reach is not permitted.

Only protection by insulation of live parts or protection by barriers or enclosures are permitted.

710:41-3 Protection against indirect contact

710:41-3.1 Automatic disconnection of supply

710:41-3.1.1 General

710:41-3.1.1.1 Disconnection of supply

In medical locations of group 1 and group 2, the following shall apply:

- for IT, TN and TT systems, the conventional touch voltage U_L shall not exceed 25 V a.c. ($U_L \leq 25$ V a.c.);
- for TN and IT systems, Table C.41-3 of Chapter 41 shall apply.

NOTE Disconnection of supply when overload or short-circuit conditions occur, can be achieved by different design methods within the procedures of the general rules in order to satisfy the required safety level.

710:41-3.1.3 TN systems

In final circuits of group 1 rated up to 32 A residual current devices with a maximum residual operating current of 30 mA shall be used (additional protection).

In medical locations of group 2, protection by automatic disconnection of supply by means of residual current protective devices with the rated residual-operating-current not exceeding 30 mA shall only be used on the following circuits:

- circuits for the supply of operating tables;
- circuits for X-ray units;

  NOTE The requirement is mainly applicable to mobile X-ray units brought into group 2 locations.
- circuits for large equipment with a rated power greater than 5 kVA;
- circuits for non-critical electrical equipment (non life support).

Care shall be taken to ensure that simultaneous use of many items of such equipment connected to the same circuit cannot cause unwanted tripping of the residual current protective device (RCD).

In medical locations of group 1 and group 2, where RCDs are required by this statement, only type A or type B shall be selected, depending on the possible fault-current arising.

NOTE It is recommended that TN-S systems are monitored to ensure the insulation level of all live conductors.

710:41-3.1.4 TT systems

In medical locations of group 1 and group 2, the requirements of TN systems (see 710:41-3.1.3) apply and in all cases residual current protective devices shall be used.

710:41-3.1.5 Medical IT system

NOTE The Medical IT system is called also an "Isolated Power System".

In group 2 medical locations, the medical IT system shall be used for circuits supplying medical electrical equipment and systems intended for life support, surgical applications and other electrical equipment located in the "patient environment", excluding equipment listed in 710:41-3.1.3. For each group of rooms serving the same function, at least one separate medical IT system is necessary. The medical IT system shall be equipped with an insulation monitoring device in accordance with SASO IEC 61557-9 having the following specific requirements:

- the a.c. internal impedance shall be at least 100 kΩ ;
- the test voltage shall not be greater than 25 V d.c.;
- the injected current, even under fault conditions, shall not be greater than 1 mA peak;
- indication yellow single lamp shall come ON when the insulation resistance has decreased to 50 kΩ . A test device shall be provided;

NOTE An indication is recommended if the earth wiring connection is lost.

For each medical IT system, an acoustic and visual alarm system incorporating the following components shall be arranged at a suitable place so that it can be permanently monitored (audible and visual signals) by the medical staff:

- a green signal lamp to indicate normal operation;
- a yellow signal lamp which lights when the minimum value set for the insulation resistance is reached. It shall not be possible for this light to be cancelled or disconnected;
- an audible alarm which sounds when the minimum value set for the insulation resistance is reached. This audible alarm may be silenced.
- the yellow signal shall go out on removal of the fault and when the normal condition is restored.

Where only one equipment is supplied from one single dedicated IT transformer, the latter can be installed without an insulation monitoring device.

Monitoring of overload and high temperature for the medical IT transformer is required.

710:41-3.1.6 Supplementary equipotential bonding

710:41-3.1.6.1 In each medical location of group 1 and group 2, supplementary equipotential bonding conductors shall be installed and connected to the equipotential bonding bus bar for the purpose of equalizing potential differences between the following parts, located in the "patient environment":

- protective conductors;
- extraneous-conductive-parts;
- screening against electrical interference fields, if installed;
- connection to conductive floor grids, if installed;
- metal screen of the isolating transformer, if any.

NOTE Fixed conductive non-electrical patient supports such as operating theatre tables, physiotherapy couches and dental chairs should be connected to the equipotential bonding conductor unless they are intended to be isolated from earth.

710:41-3.1.6.2 In medical locations of group 2, the resistance of the conductors, including the resistance of the connections, between the terminals for the protective conductor of socket-outlets and of fixed equipment or any

extraneous-conductive-parts and the equipotential bonding bus bar shall not exceed 0.2 Ω .

NOTE This resistive value can also be determined by the use of a suitable cross-sectional area of the conductor.

710:41-3.1.6.3 The equipotential bonding bus bar shall be located in or near the medical location. In each distribution board or in its proximity, an additional equipotential bonding bar shall be provided to which the supplementary equipotential bonding conductor and protective earth conductor shall be connected. Connections shall be so arranged that they are clearly visible and easily disconnected individually.

710:42-2 Fire protection

Civil Deffence legislation providing additional requirements for fire protection shall be used if exists.

710:51 Common rules

710:51-2 Operational conditions and external influences

710:51-2.1 Operating conditions

710:51-2.1.1 Transformers for medical IT systems

Transformers shall be installed in close proximity to, inside or outside, the medical location and placed in cabinets or enclosures to prevent unintentional contact with live parts.The rated voltage U_{n} on the secondary side of transformers shall not exceed 250 V a.c.

710:51-2.1.2 Medical IT systems for group 2 medical locations

Transformers shall be in accordance with, SASO IEC 61558-2-15, they should comply with the following additional requirements:

The leakage current of the output winding to earth and the leakage current of the enclosure, when measured in no-load condition and the transformer supplied at rated voltage and rated frequency, shall not exceed 0.5 mA.

Single-phase transformers shall be used to form the medical IT systems for portable and fixed equipment and the rated output shall not be less than 0.5 kVA and shall not exceed 10 kVA.

If the supply of three-phase loads via an IT system is also required, a separate three-phase transformer shall be provided for this purpose with output line-to-line voltage not exceeding 250 V.

710:51-2.2 External influences

NOTE Where appropriate, attention should be given to prevention of electromagnetic interference.

710:51-2.2.1 Explosion risk locations

NOTE 1 Requirements for medical electrical equipment for use in conjunction with flammable gases and vapours are contained in SASO IEC 60601-1.

NOTE 2 Where hazardous conditions are likely to occur (e.g. in the presence of flammable gases and vapours), special precautions indicated in this statement are required.

NOTE 3 Prevention of build-up of static electricity is recommended.

Electrical devices (e.g. socket-outlets and switches) shall be installed at a distance of at least 0.2 m horizontally (center to center) from any medical gas-outlets, so as to minimize the risk of ignition of flammable gases.

710:51-2.2.1.1 Classification

a) Hazardous location

1) Use location

In a location where flammable medical gases are used or where flammable anesthetics are employed, the entire area shall be considered to be a hazardous location that shall extend upward to a level 1.5 m above the floor. The remaining volume up to the structural ceiling is considered to be above the hazardous location.

2) Storage location

Any room or location in which flammable anesthetics or volatile flammable disinfecting agents or flammable medical gases are stored shall be considered to be a hazardous location from floor to ceiling.

b) Other-than-hazardous locations

Any location designated for the exclusive use or storage of nonflammable anesthetizing agents or gases shall be considered to be an other-than-hazardous location.

710:51-2.2.1.2 Wiring and Equipment

a) Within Hazardous Locations

1) **Isolation:** Each power circuit within, or partially within, a hazardous location shall be isolated from any distribution system by the use of an isolated power system.

2) **Design and installation:** Isolated power system equipment shall be listed for the purpose and the system designed and installed so that it meets the provisions and is in accordance with this statement.

3) **Equipment operating at more than 10 volts**: In hazardous locations all fixed wiring and equipment and all portable equipment, including lamps and other utilization equipment, operating at more than 10 volts between conductors shall comply with the requirements of Chapter 720.

4) **Socket-outlets and attachment plugs:** Socket-outlets and attachment plugs in a hazardous location(s) shall be listed for use in hazardous locations and shall have provision for the connection of an earthing conductor.

5) **Flexible cord type:** Flexible cords used in hazardous locations for connection to portable utilization equipment, including portable lamps , shall be of a type approved for extra-hard usage and shall include an additional conductor for earthing.

b) Above Hazardous Locations

1) **Wiring methods:** Wiring above a hazardous location shall be installed in rigid metal conduit, electrical metallic tubing, intermediate metal conduit, cable that employs a continuous, gas/vaportight metal sheath.

2) **Equipment enclosure:**

- Installed equipment that may produce arcs, sparks, or particles of hot metal, such as lamps and lampholders for fixed lighting, cutouts, switches, generators, motors, or other equipment having make-and-break or sliding contacts, shall be totally enclosed type or be constructed so as to prevent escape of sparks or hot metal particles.

- Wall-mounted socket-outlets installed above the hazardous location in flammable anesthetizing locations are permitted to be not totally enclosed or screened to prevent dispersion of particles.

3) **Luminaires (lighting fixtures):**
   - Surgical and other luminaires (lighting fixtures) shall conform to 55-9.11 and Chapter 720.
   - Integral or pendant switches that are located above and cannot be lowered into the hazardous location(s) shall not be required to be explosionproof.

4) **Socket-outlets and attachment plug:** Socket-outlets and attachment plugs located above hazardous anesthetizing locations shall be listed for hospital use for services of prescribed voltage, frequency, rating, and number of conductors with provision for the connection of the earthing conductor.

   Socket-outlets and attachment plugs, for connection of medical equipment for use above hazardous locations shall be arranged so that socket-outlets will accept attachment plug having same or lower ratings. The attachment plugs shall be of the 2-pole, 3-wire design with a third contact connecting to the insulated (green with yellow stripe) equipment earthing conductor of the electrical system.

c) **Other-Than-Hazardous Locations**

1) **Wiring methods:** Wiring serving other-than-hazardous locations, shall be installed in a metal raceway system or cable assembly. The metal raceway system or cable armor or sheath assembly shall qualify as equipment earthing return path.

   Pendant socket-outlets constructions that employ flexible cords suspended not less than 1.8 m from the floor shall not be required to be installed in a metal raceway or cable assembly.

2) **Socket-outlets and Attachment Plugs:** Socket-outlets and attachment plugs installed and used in other-than-hazardous locations shall be listed for hospital use for services of prescribed voltage, frequency, rating, and number of conductors with provision for connection of the earthing conductor. This requirement shall apply to 2-pole, 3-wire earthing type for single-phase.

710:51-2.2.1.3 Earthing

In any anesthetizing area or flammable medical gases location , all metal raceways and metal-sheathed cables and all non–current-carrying conductive portions of fixed electric equipment shall be earthed. Earthing shall comply with requirements of Chapter 720 (Hazardous Locations).

Equipment operating at not more than 10 volts between conductors shall not be required to be earthed.

a) **Earthed Power Systems in Anesthetizing Locations**

1) **Circuit Wiring:** Circuits supplying only listed, fixed, therapeutic and diagnostic equipment, permanently installed above the hazardous location and in other-than-hazardous locations, shall be permitted to be supplied from a normal earthed service (TN or TT), single- or three-phase system, provided the following apply:

- Wiring for earthed and isolated circuits does not occupy the same raceway or cable.
- All conductive surfaces of the equipment are earthed.
- Equipment (except enclosed X-ray tubes and the leads to the tubes) are located at least 2.5 m above the floor or outside the anesthetizing location.
- Switches for the earthed circuit are located outside the hazardous location.

2) **Fixed Lighting Circuits:** Circuits supplying only fixed lighting shall be permitted to be supplied by a normal earthed service, provided the following apply:
   - Such luminaires (fixtures) are located at least 2.5 m above the floor.
   - All conductive surfaces of luminaires (fixtures) are earthed.
   - Wiring for circuits supplying power to luminaires (fixtures) does not occupy the same raceway or cable for circuits supplying isolated power.
   - Switches are wall-mounted and located above hazardous locations.

3) **Remote-Control Stations:** Wall-mounted remote-control stations for remote-control switches operating at 24 volts or less shall be permitted to be installed in any anesthetizing location.

4) **Location of Isolated Power Systems:** An isolated power center listed for the purpose and its earthed primary feeder shall be permitted to be located in an anesthetizing location, provided it is installed above a hazardous location or in an other-than-hazardous location.

5) **Circuits in Anesthetizing Locations:** Except as permitted above, each power circuit within, or partially within, a flammable anesthetizing location shall be isolated from any distribution system supplying other-than-anesthetizing locations.

710:51-2.3 Low-Voltage Equipment and Instruments.

a) **Equipment Requirements:** Low-voltage equipment that is frequently in contact with the bodies of persons or has exposed current-carrying elements shall be as follows:
   - Operate on an electrical potential of 10 volts or less, or
   - Approved as intrinsically safe or double-insulated equipment, or
   - Moisture resistant

b) **Power Supplies:** Power shall be supplied to low-voltage equipment from the following:
   - An individual portable isolating transformer (autotransformers shall not be used) connected to an isolated power circuit socket-outlet by means of an appropriate cord and attachment plug, or
   - A common low-voltage isolating transformer installed in an other-than-hazardous location, or
   - Individual dry-cell batteries, or
   - Common batteries made up of storage cells located in an other-than-hazardous location.

c) **Isolated Circuits:** Isolating-type transformers for supplying low-voltage circuits shall have the following:
   - Approved means for insulating the secondary circuit from the primary circuit, and
   - The core and case earthed.

d) **Controls:** Resistance or impedance devices shall be permitted to control low-voltage equipment but shall not be used to limit the maximum available voltage to the equipment.

e) **Battery-Powered Appliances:** Battery-powered shall not be capable of being charged while in operation unless their charging circuitry incorporates an integral isolating-type transformer.

f) **Socket-outlets or Attachment Plugs:** Any socket-outlets or attachment plug used on low-voltage circuit shall be of a:

- Fixed and Stationary Equipment. Fixed and stationary X-ray equipment shall be connected to the power supply by means of a wiring method that meets the general requirements of these Electrical Requirements.

  Equipment properly supplied by a circuit rated not more 30 amperes shall be permitted to be supplied through a suitable attachment plug and hard-service cable or cord according to the requirment of 55-8.
- Portable, Mobile, and Transportable Equipment. Individual circuits shall not be required for portable, mobile, and transportable medical X-ray equipment having a capacity of not mor than 60 amperes.

710:51-4.5 **Diagrams, documentation and operating instructions**

Plans of the electrical installation together with records, drawings, wiring diagrams and modifications thereto, as well as instructions for operation and maintenance, shall be provided for the user.

NOTE Drawings and wiring diagrams should be in accordance with SASO IEC 60617-1, 2, 3, 6, 7, 8 and SASO IEC 61082-1.

The relevant documents are in particular:

- block diagrams showing the distribution system of the normal power supply and power supply for safety services in a single-line representation. These diagrams shall contain information on the location of the sub-distribution boards within the building;
- main and sub-distribution board block diagrams showing switchgear and controlgear and distribution boards in a single-line representation;
- architectural diagrams according to SASO IEC 60617-DB;
- schematic diagrams of controls;
- instructions for operation, inspection, testing and maintenance of storage batteries and power sources for safety services;
- computational verification of compliance with the requirements of standards (e.g. with 710:41-3.1);
- list of loads permanently connected to the power supply for safety services indicating the normal currents and, in the case of motor-operated loads, the starting currents;
- a logbook containing a record of all tests and inspections which require to be completed prior to commissioning.

710:52 **Wiring systems**

710:52-0.1 Any wiring system within group 2 medical locations shall be exclusive to the use of equipment and fittings in that location.

710:52-0.2 **Capacity of systems:** The essential electrical wiring system shall have adequate capacity to meet the demand for the operation of all functions and equipment to be served by each system and circuit within group 2 medical locations.

Feeders shall be sized to meet sufficient capacity and proper rating for the demand produced by the load of the essential electrical system(s) at any given time.

Demand calculations for sizing of main and branch feeders shall be based on the following:

- Prudent demand and diversity factors and historical data, or
- Connected load, or
- Feeder calculation procedures described in Chapter 52, or
- Any combination of the above.

710:53 **Isolation, switching and control**

710:53-3 **Protection of wiring systems in medical locations of group 2**

Overcurrent protection against short-circuit and overload current is necessary for each final circuit. Overload current protection is not allowed in the feeder circuits upstream and downstream of the transformer of medical IT-system. Fuses may be used for short-circuit protection.

710:55 **Other equipment**

710:55-6 **Safety services**

710:55-6.5.2 **Sources**

Classification of safety services are given in Annex A.710.

710:55-6.5.2.1 **General requirements for safety power supply sources of group 1 and group 2**

710:55-6.5.2.1.1 In medical locations, a power supply for safety services is required which, in case of a failure of the normal power supply source, shall be energized to feed the equipment stated in : 710:55-6.5.2.2.1, 710:55-6.5.2.2.2 and 710:55-6.5.2.2.3 with electrical energy for a defined period of time and within a pre-determined changeover period.

710:55-6.5.2.1.2 If the voltage at the main distribution board drops in one or several line conductors by more than 10 % of the nominal voltage in a steady condition a safety power supply source shall assume the supply automatically.

The supply transfer should be achieved with a delay in order to cater for auto re-closure of circuit-breakers of incoming supplies (short-time interruptions).

710:55-6.5.2.1.3 For interconnecting cables between the individual components and sub-assemblies of safety power supply sources, see 710:52.

NOTE The circuit which connects the power supply source for safety services to the main distribution board should be considered a safety circuit.

710:55-6.5.2.2 **Detailed requirements for safety power supply services**

710:55-6.5.2.2.1 **Power supply sources with a change-over period less than or equal to .5 s**

In the event of a voltage failure of one or more line conductors at the distribution board, a special safety power supply source shall maintain

luminaires of operating theatre tables and other essential luminaires, e.g. endoscopes, for a minimum period of 3 h. It shall restore the supply within a changeover period not exceeding 0.5 s (class 0.5: short break, see Table A.710-1).

710:55-6.5.2.2.2 Power supply sources with a change-over period less than or equal to 15 s

Equipment according to 710:55-6.7.5 and 710:55-6.8 shall be connected within 15 s to a safety power supply source capable of maintaining it for a minimum period of 24 h, when the voltage of one or more line conductors at the main distribution board for the safety services has decreased in steady condition by more than 10 % of the nominal value of supply voltage and of a duration greater than 3 s.

NOTE The duration of 24 h can be reduced to a minimum of 3 h if the medical requirements and the use of the location, including any treatment, can be concluded and if the building can be evacuated in a time which is well within 24 h.

710:55-6.5.2.2.3 Power supply sources with a changeover period greater than 15 s

Equipment other than those covered by 710:55-6.5.2.2.1 and 710:55-6.5.2.2.2, which is required for the maintenance of hospital services, may be connected either automatically or manually to a safety power supply source capable of maintaining it for a minimum period of 24 h. This equipment may include, for example:

- sterilization equipment;
- technical building installations, in particular air conditioning, heating and ventilation systems, building services and waste disposal systems;
- cooling equipment;
- cooking equipment;
- storage battery chargers.

710:55-6.7 Safety lighting circuits

710:55-6.7.5 Safety lighting

In the event of mains power failure, the necessary minimum illuminance shall be provided from the safety services source for the following locations. The change-over period to the safety source shall not exceed 15 s:

- escape routes;
- lighting of exit signs;
- locations for switchgear and controlgear for emergency generation sets and for main distribution boards of the normal power supply and for power supply for safety services;
- rooms in which essential services are intended. In each room at least one luminaire shall be supplied from the power source for safety services;
- rooms of group 1 medical locations. In each room at least one luminaire shall be supplied from the power supply source for safety services;
- rooms of group 2 medical locations. A minimum of 50 % of the lighting shall be supplied from the power source for safety services.

NOTE The values for minimum illuminance is given by SASO 2012.

710:55-6.8 **Other services**

Services other than lighting which require a safety service supply with a changeover period not exceeding 15 s may include, for example, the following:

- selected lifts for firemen;
- ventilating systems for smoke extraction;
- paging systems;
- medical electrical equipment used in group 2 medical locations which serves for surgical or other measures of vital importance. Such equipment will be defined by responsible staff;
- electrical equipment of medical gas supply including compressed air, vacuum supply and narcosis (anaesthetics) exhaustion as well as their monitoring devices;
- fire detection, fire alarms and fire extinguishing systems.

710:55-7 **Socket-outlet circuits in the medical IT system for medical locations of group 2**

Each patient bed location shall be provided with a minimum of six socket-outlets supplied by at least two circuits, one or more from the emergency system and one or more circuits from the normal system. Emergency system socket-outlets shall be identified and shall also indicate the panelboard and circuit number supplying them.

At each patient's place of treatment, e.g. bedheads, the configuration of socket-outlets shall be as follows:

- either a minimum of two separate circuits feeding socket-outlets shall be installed; or
- each socket-outlet shall be individually protected against overcurrent.

Where circuits are supplied from other systems (TN-S or TT systems) in the same medical location, socket-outlets connected to the medical IT system shall either:

- be of such construction that prevents their use in other systems, or
- be clearly and permanently marked.

710:55-9 **Luminaires and lighting installation**

In medical locations of group 1 and group 2, at least two different sources of supply shall be provided for some of the luminaires by two circuits. One of the two circuits shall be connected to the safety service. In escape routes, alternate luminaires shall be connected to the safety service (see 710:55-6).

710:61 **Initial verification**

The dates and results of each verification shall be recorded.

The tests specified below under items a) to e) in addition to the requirements of chapter 61, shall be carried out, both prior to commissioning and after alterations or repairs and before re-commissioning.

a) Functional test of insulation monitoring devices of medical IT systems and acoustical/visual alarm systems.

b) Measurements to verify that the supplementary equipotential bonding is in accordance with 710:41-3.1.6.1 and 710:41-3.1.6.2.

c) Verification of the integrity of the facilities required with 710:41-3.1.6.3 for equipotential bonding.
d) Verification of the integrity of the requirements of 710:55-6 for safety services.
e) Measurements of leakage current of the output circuit and of the enclosure of medical IT transformers in no-load condition.

710:62 **Periodic verification**

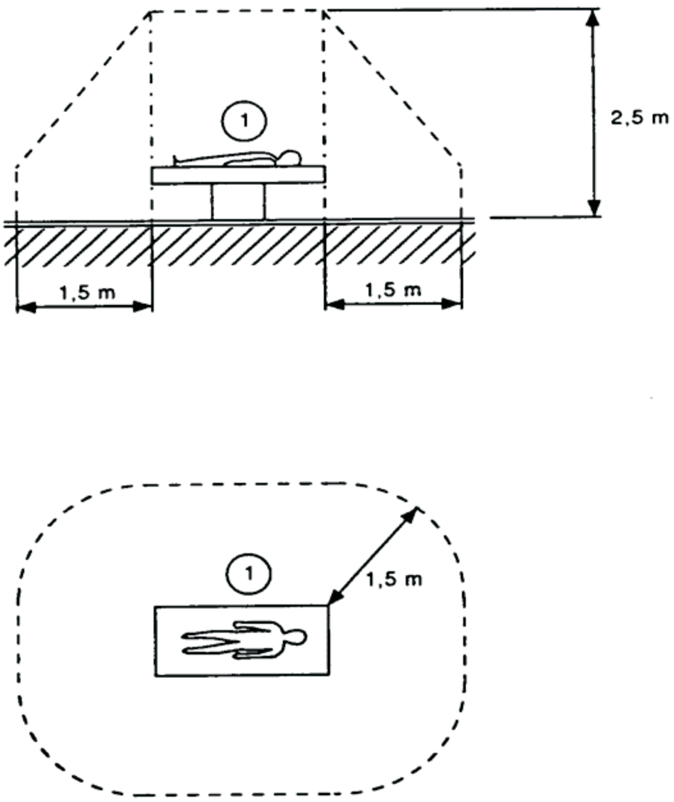
The dates and results of each verification shall be recorded.

Periodic verification of items a) to e) of 710:61 shall be carried out in accordance with the following intervals:

a) functional testing of changeover devices: 12 months;
b) functional testing of insulation monitoring devices: 12 months;
c) checking, by visual inspection, settings of protective devices: 12 months;
d) measurement verifying the supplementary equipotential bonding: 36 months ;
e) verifying integrity of facilities required for equipotential bonding: 36 months;
f) monthly functional testing of:
- safety services with batteries: 15 min;
- safety services with combustion engines: until rated running temperature is achieved; 12 months for "endurance run";
- safety services with batteries: capacity test;
- safety services with combustion engines: 60 min.

In all cases at least 50 % to 100 % of the rated power shall be taken over.

g) measurement of leakage currents of IT transformers: 36 months;
h) checking of the tripping of RCDs at $I_{\Delta N}$: not less than 12 months.



NOTE Dimensions shown are not prescriptive.

Figure 710-1 Example of patient environment SASO IEC 60601-1-1.

Annex A.710
(normative)

Classification of Safety Services for Medical Locations

Table A.710-1 Classification of safety services necessary for medical locations
(see also 55-6.1 of Chapter 55)

Class 0 (no-break)	Automatic supply available at no-break
Class 0.15 (very short break)	Automatic supply available within 0.15 s
Class 0.5 (short break)	Automatic supply available within 0.5 s
Class 15 (medium break)	Automatic supply available within 15 s
Class >15 (long break)	Automatic supply available in more than 15 s
NOTE 1 Generally it is unnecessary to provide a no-break power supply for medical electrical equipment. However, certain microprocessor-controlled equipment may require such a supply. NOTE 2 Safety services provided for locations having differing classifications should meet that classification which gives the highest security of supply. Refer to Annex B.710 for guidance on the association of classification of safety services with medical locations. "within" implies "≤".	

Annex B.710
(informative)

Examples for Allocation of Group Numbers and Classification for Safety Services of Medical Locations

A definitive list of medical locations showing their assigned groups is impracticable, as the use to which locations (rooms) might be put will differ between countries and even within a country. The accompanying list of examples is provided as a guide only.

Table B.710-1 List of examples

Medical location	Group			Class	
	0	1	2	≤ 0.5 s	>0.5 s ≤ 15 s
1. Massage room	X	X			X
2. Bedrooms		X			
3. Delivery room		X		X [a]	X
4. ECG, EEG, EHG room		X			X
5. Endoscopic room		X [b]			X [b]
6. Examination or treatment room		X			X
7. Urology room		X [b]			X [b]
8. Radiological diagnostic and therapy room, other than mentioned under 21		X			X
9. Hydrotherapy room		X			X
10. Physiotherapy room		X			X
11. Anaesthetic room			X	X [a]	X
12. Operating theatre			X	X [a]	X
13. Operating preparation room		X	X	X [a]	X
14. Operating plaster room		X	X	X [a]	X
15. Operating recovery room		X	X	X [a]	X
16. Heart catheterization room			X	X [a]	X
17. Intensive care room			X	X [a]	X
18. Angiographic examination room			X	X [a]	X
19. Haemodialysis room		X			X
20. Magnetic resonance imaging (MRI) room		X			X
21. Nuclear medicine		X			X
22. Premature baby room			X	X [a]	X

[a] Luminaires and life-support medical electrical equipment which needs power supply within 0.5 s or less.

[b] Not being an operating theatre.

Explanations of terms listed in Table B.710-1

1. Massage room
2. General ward (bedrooms)

   Medically used room or group of rooms in which patients are accommodated for the duration of their stay in a hospital, or in any other medical establishment.
3. Delivery room

   Room in which the birth takes place.
4. Electrocardiography room (ECG), electroencephalography room (EEG), electrohysterography room (EHG)
5. Endoscopic room

   Room intended for application of endoscopic methods for the examination of organs through natural or artificial orifices.

   Examples of endoscopic methods are bronchoscopic, laryngoscopic, cystoscopic, gastroscopic and similar methods, if necessary performed under anaesthesia.
6. Examination or treatment room
7. Urology room (not being an operating theatre)

   Room in which diagnostic or therapeutic procedures are performed on the urogenital tract using medical electrical equipment, such as X-ray equipment, endoscopic equipment and high-frequency surgery equipment.
8. Radiological diagnostic room (radiological diagnostic and therapy room)

   Radiological diagnostic room.

   Room intended for the use of ionizing radiation for display of internal structures of the body by means of radiography or fluoroscopy or by the use of radio-active isotopes or for other diagnostic purposes.

   Therapy room.

   Room intended for the use of ionizing radiation to obtain therapeutic effects.
9. Hydrotherapy room

   Room in which patients are treated by hydrotherapeutic methods. Examples of such methods are therapeutic treatments with water, brine, mud, slime, clay, steam, sand, water with gases, brine with gases, inhalation therapy, electrotherapy in water (with or without additions), massage thermotherapy and thermotherapy in water (with or without additions).

   Swimming pools for general use and normal bathrooms are not considered as hydrotherapy rooms.
10. Physiotherapy room

    Room in which patients are treated by physiotherapeutic methods.
11. Anaesthetic room

    Medically used room in which general inhalation anaesthetics are administered.

    NOTE The anaesthetic room comprises for instance the actual operating theatre, the operating preparation room, the operating plaster room and treatment room.
12. Operating theatre

    Room in which surgical operations are performed.
13. Operating preparation room

    Room in which patients are prepared for an operation, e.g. by administering anaesthetics.

14. Operating plaster room

    Room in which plaster of Paris or similar dressings are applied while anaesthesia is maintained.

    NOTE Such a room belongs to the operating room group and is usually spatially connected to it.

15. Operating recovery room

    Room in which the patient under observation recovers from the influence of anaesthesia

    NOTE Such a room is usually very close to the operating room group but not necessarily part of it.

16. Heart catheterization room

    Room intended for the examination or treatment of the heart using catheters. Examples of applied procedures are measurement of action potentials of the haemodynamics of the heart, drawing of blood samples, injection of contrast agents or application of stimulants.

17. Intensive care room

    Room in which bed patients are monitored independently of an operation by means of medical electrical equipment. Body actions may be stimulated if required.

18. Angiographic examination room

    Room intended for displaying arteries or veins, etc. with contrast media.

19. Haemodialysis room

    Room in a medical establishment intended to connect patients to medical electrical equipment in order to detoxicate their blood.

20. Magnetic resonance imaging (MRI)
21. Nuclear medicine
22. Premature baby room

CHAPTER 711
EXHIBITIONS, SHOWS AND STANDS

711:11 **Scope**

The particular requirements of this chapter, in association with other parts of these Electrical Requirements, apply to the temporary electrical installations in exhibitions, shows and stands (including mobile and portable displays and equipment) to protect users.

711:31 **Purposes, supplies and structure**

711:31-3 **Supplies**

711:31-3.1.3 **Voltage**

The nominal supply voltage of temporary electrical installations in exhibitions, shows and stands shall not exceed 230/400 V a.c. (see SASO 182).

711:31-3.3 **Supply from the public network**

Irrespective of the number of sources of supply, the phase and neutral conductors from different sources shall not be interconnected. The instructions of the supply network operator shall be followed.

711:41 **Protection against electric shock**

711:41-0.3 **Application of measures of protection against electric shock**

711:41-0.3.2 **Application of measures of protection against direct contact**

Protective measures against direct contact by means of obstacles (see 41-2.3 of Chapter 41) and by placing out of reach (see 41-2.4 of Chapter 41) shall not be used.

711:41-0.3.3 **Application of measures of protection against indirect contact**

Protective measures against indirect contact by non-conducting location (see 41-3.3 of Chapter 41) and by earth-free equipotential bonding (see 41-3.4 of Chapter 41) shall not be used.

711:41-0.3.4 **Application of measures of protection in relation to external influences**

711:41-0.3.4.3.1 Automatic supply disconnection of cables which are intended to supply temporary structures should be provided at the origin by residual current devices whose rated residual operating current does not exceed 500 mA. These devices shall provide a delay by using a device in accordance with SASO IEC 60947-2, or be of the S-type in accordance with SASO IEC 61008-1 or SASO IEC 61009-1 for discrimination with RCDs protecting final circuits.

NOTE The recommendation for additional protection relates to the increased risk of damage to cables in temporary locations.

711:41-1.1.4 **Requirements for unearthed circuits (SELV)**

711:41-1.1.4.3 Where SELV is used, the protection of conductors shall be provided by insulation capable of withstanding a test voltage of 500 V a.c. for 1 min, or by barriers or enclosures affording a degree of protection of at least IP4X or IPXXD.

711:41-1.1.5 **Requirements for earthed circuits (PELV)**

711:41-1.1.5.1 Where PELV is used, the protection of conductors shall be provided by insulation capable of withstanding a test voltage of 500 V a.c. for 1 min, or by barriers or enclosures affording a degree of protection of at least IP4X or IPXXD.

711:41-3.1 **Protection by automatic disconnection of supply**

711:41-3.1.3 **TN system**

Where the type of system earthing is TN, the installation shall be TN-S.

711:41-3.1.3.3 For the application of protective measures against indirect contact by automatic disconnection of supply, the conventional touch voltage limit in locations in which animals are kept is U_L= 25 V a.c. or 60 V d.c. and the maximum disconnecting time is that indicated in Chapter 41, table 41-3.

These conditions are also applicable in locations connected by extraneous-conductive-parts to the locations where animals are kept.

711:41-3.1.6 **Supplementary equipotential bonding**

711:41-3.1.6.1 In locations used for animals, supplementary equipotential bonding shall connect all exposed-conductive-parts and extraneous-conductive-parts which can be touched simultaneously, and the protective conductor of the installation.

If a metallic grid is laid in the floor, it shall be connected to the local supplementary bonding required for locations where animals are kept.

711:41-3.1.6.2 The extraneous-conductive-parts of a vehicle, wagon, caravan or container shall be bonded to the protective conductor of the installation in more than one place if the type of construction does not ensure continuity. The nominal cross-sectional area of conductors used for this purpose shall be not less than 4 mm^2 copper.

If the vehicle, wagon, caravan or container is made substantially of insulating material, these requirements do not apply to metal parts, which are unlikely to become live in the event of a fault.

711:42 **Protection against thermal effects**

NOTE Attention is drawn to the increased risk of fire and burns in these locations and the need to comply with the requirements of Chapter 42.

711:42-2 **Measures for protection against fire**

711:42-2.3 **Nature of processed or store materials**

NOTE This should be taken into consideration when assessing the external influence conditions according to Table 51-1.

711:42-2.3.8 A motor which is automatically or remotely controlled and which is not continually supervised shall be fitted with a manual reset protective device against excess temperature.

711:42-2.4 **Combustible constructional materials**

711:42-2.4.2 **Heat generation**

Lighting equipment such as incandescent lamps, spotlights and small projectors, and other equipment or with high temperature surfaces shall be suitably guarded, and installed and located in accordance with the relevant

standard. All such equipment shall be arranged well away from combustible material to prevent contact.

Showcases and signs shall be constructed of materials having an adequate heat resistance, mechanical strength, electrical insulation and ventilation, taking into account the combustibility of exhibits in relation to the heat generation.

Stand installations containing a concentration of electrical apparatus, lighting fittings or lamps liable to generate excessive heat shall not be installed unless adequate ventilation provisions are made, e.g. well-ventilated ceilings constructed of in combustible material.

711:51 **Common rules**

Control and protective switchgear shall be placed in closed cabinets which can only be opened by the use of a key or a tool, except for those parts designed and intended to be operated by ordinary persons (BA1), as defined in Table 51-1.

711:51-2.2 **Classification of external influences**

The external influence conditions are those of the particular locations where temporary electrical installations are erected, e.g. presence of water, mechanical stresses.

711:51-4 **Identification**

ELV transformers and converters shall be clearly labelled, stating:

- the precise details of any integral secondary circuit protective devices;
- that they are manual reset;
- the rated power output in VA;
- the rated secondary voltage in V.

711:52 **Wiring systems**

Armoured cables or cables protected against mechanical damage shall be used wherever there is a risk of mechanical damage.

Wiring cables shall be copper and have a minimum cross-sectional area of 1.5 mm^2, and they shall comply with SASO IEC 60227, SASO 595, SASO 596, SASO 597, or SASO 598 as appropriate.

Trailing flexible cords shall not exceed 2 m in length.

711:52-1 **Types of wiring systems**

Where no fire alarm system is installed in a building used for exhibitions etc. cable systems shall be either

- flame retardant to SASO 752 or SASO 1274, and low smoke to SASO IEC 61034, or
- single or multicore unarmoured cables enclosed in metallic or non-metallic conduit or trunking, providing fire protection in accordance with SASO 254, SASO 255, SASO 1901 and SASO 1902 or SASO IEC 61084 and providing a degree of protection of at least IP4X.

711:52-6 **Electrical connections**

711:52-6.1 Joints shall not be made in cables except where necessary as a connection into a circuit. Where joints are made, these shall be either using connectors in accordance with the relevant Saudi Standards or the connection shall be made in an enclosure with a degree of protection of at least IP4X or IPXXD.

Where strain can be transmitted to terminals the connection shall incorporate cable anchorage(s).

NOTE The degree of protection specified relates to the particular danger of wire coat hangers and other temporary wire hangers used by exhibitors (ordinary persons) in exhibitions, shows and stands.

711:53 Isolation, switching and control

711:53-6.2 Isolation

711:53-6.2.1.5 Every separate temporary structure, such as a vehicle, a stand or a unit, intended to be occupied by one specific user and each distribution circuit supplying outdoor installations shall be provided with their own readily accessible and properly identifiable means of isolation.

711:53-6.2.1.6 Isolation of electric motors

Where an electric motor might give rise to a hazard, the motor shall be provided with an effective means of isolation on all poles and such means shall be adjacent to the motor which it controls (see SASO IEC 60204-1).

711:55 Other equipment

711:55-1 Low-voltage generating sets

All generators shall be so located or protected as to prevent danger and injury to people through inadvertent contact with hot surfaces and dangerous parts. Reference to injury and danger in this statement also includes non-electrical danger and injury.

Electrical equipment associated with the generator shall be mounted securely and, if necessary, on anti-vibration mountings.

Significant changes in generator frequency and/or voltage shall be prevented.

Where a generator is installed to supply a temporary installation, using TN, TT or IT system, care shall be taken to ensure that the earthing arrangements comply with 54-2.1 of Chapter 54 and, where earth electrodes are used, with 54-2.2 of Chapter 54.

For TN systems all exposed-conductive-parts shall be bonded back to the generator using a protective conductor cross-sectional area in accordance with 54-3.1 of Chapter 54.

The neutral conductor or star-point of the generator shall be connected to the exposed-conductive-parts of the generator.

NOTE This requirement is not applicable for IT systems.

711:55-2 ELV transformers and electronic converters

Multiple connection extra low-voltage (ELV) transformers shall conform to SASO IEC 60742 or provide an equivalent degree of safety.

A manual reset protective device shall protect the secondary circuit of each transformer or electronic converter.

Particular care shall be taken when installing ELV transformers, which shall be mounted out of arm’s reach of the public and shall have adequate ventilation. Access by skilled or instructed persons for testing and maintenance shall be provided. Electronic converters shall conform with SASO IEC 61046.

711:55-3 Socket-outlets and plugs

An adequate number of socket-outlets shall be installed to allow the users’ requirements to be met safely.

Where a floor mounted socket-outlet is installed, it shall be adequately protected from the accidental ingress of water.

Not more than one flexible cable or cord shall be connected to a plug.
Multi-way plug-in type adapters shall not be used.
The use of portable multi-way socket-outlet units shall be restricted to the following:

- one unit per fixed socket-outlet, and
- a maximum flexible cable or cord length of 2 m from plug to unit.

711:55-9 Luminaires and lighting installation

711:55-9.4 General requirements for installation

711:55-9.4.1 Luminaires

Luminaires mounted below 2.5 m (arm's reach) from floor level or otherwise accessible to accidental contact shall be firmly and adequately fixed, and so sited or guarded as to prevent risk of injury to persons or ignition of materials.

711:55-9.4.2 Lampholders

Insulation piercing lampholders shall not be used unless the cables and lampholders are compatible, and providing the lampholders are non-removable once fitted to the cable.

711:55-9.4.3 Electrical discharge lamp installations

Installations of any luminous tube sign or lamp as an illuminated unit on a stand, or as an exhibit with nominal supply voltage higher than 220/380 V a.c., shall conform to the following conditions.

711:55-9.4.3.1 Location

The sign or lamp shall be installed out of arm’s reach or shall be adequately protected to reduce the risk of injury to persons.

711:55-9.4.3.2 Installation

The facia or stand fitting material behind luminous tube signs or lamps shall be non-ignitable and protected as required by Saudi Standards.
Controlgear with output voltages higher than 220/380 V a.c. shall be mounted on non-ignitable material.

711:55-9.4.3.3 Emergency switching devices

A separate circuit shall be used to supply such signs, lamps or exhibits, which shall be controlled by an emergency switch.
The switch shall be easily visible, accessible and marked in accordance with the requirements of the local authority.

711.61 Verification

The temporary electrical installation of exhibitions, shows and stands shall be tested on site in accordance with Chapter 61 after each assembly on site.

CHAPTER 712
SOLAR PHOTOVOLTAIC (PV) POWER SUPPLY SYSTEMS

712:11 Scope

The particular requirements of this chapter apply to the electrical installations of PV power supply systems including systems with AC modules.

712:31 Purpose, supplies and structure

712:31-2 Types of distribution systems

712:31-2.2 Types of system earthing

Earthing of one of the live conductors of the DC side is permitted, if there is at least simple separation between the AC side and the DC side.

NOTE Any connections with earth on the DC side should be electrically connected so as to avoid corrosion.

712:41 Protection against electric shock

PV equipment on the DC side shall be considered to be energized, even when the system is disconnected from the AC side.

The selection and erection of equipment shall facilitate safe maintenance and shall not adversely affect provisions made by the manufacturer of the PV equipment to enable maintenance or service work to be carried out safely.

712:41-1 Protection against both direct and indirect contact

712:41-1.1 Protection by extra-low-voltage: SELV and PELV

For SELV and PELV systems, $U_{\mathrm{OC\ STC}}$ replaces U_{n} and shall not exceed 120 V DC.

712:41-3 Fault protection

712:41-3.1 Protection by automatic disconnection of supply

NOTE Protection by automatic disconnection of supply on the DC side requires special measures.

712:41-3.1.1.1.1 On the AC side, the PV supply cable shall be connected to the supply side of the protective device for automatic disconnection of circuits supplying current-using equipment.

712:41-3.1.1.1.2 Where an electrical installation includes a PV power supply system without at least simple separation between the AC side and the DC side, an RCD installed to provide fault protection by automatic disconnection of supply shall be type B according to SASO IEC 60755.

Where the PV inverter by construction is not able to feed DC fault currents into the electrical installation, an RCD of type B according to SASO IEC 60755 is not required.

712:41-3.2 Protection by use of class II or equivalent insulation should preferably be adopted on the DC side.

712:41-3.3 Protection by non-conducting locations is not permitted on the DC side.

712:41-3.4 Protection by earth-free local equipotential bonding is not permitted on the DC side.

712:43 Protection against overcurrent

712:43-3 Protection against overload on the DC side

712:43-3.1 Overload protection may be omitted to PV string and PV array cables when the continuous current-carrying capacity of the cable is equal to or greater than 1.25 times $I_{SC\ STC}$ at any location.

712:43-3.2 Overload protection may be omitted to the PV main cable if its continuous current-carrying capacity is equal to or greater than 1.25 times $I_{SC\ STC}$ of the PV generator.

NOTE The requirements of 712:43-3.1 and 712:43-3.2 are only relevant for protection of the cables. See as well the manufacturer's instructions for protection of PV modules.

712:43-4 Protection against short-circuit currents

712:43-4.1 The PV supply cable on the AC side shall be protected by a short-circuit or an overcurrent protective device installed at the connection to the AC mains.

712:44 Protection against voltage disturbances and electromagnetic disturbances

712:44-4 Protection against electromagnetic interference (EMI) in buildings

712:44-4.4.4 To minimize voltages induced by lightning, the area of all wiring loops shall be as small as possible.

712:51 Common rules

712:51-1 Compliance with standards

712:51-1.1 PV modules shall comply with the requirements of the relevant equipment standard, e.g. SASO IEC 61215 for crystalline PV modules. PV modules of class II construction or with equivalent insulation are recommended if $U_{OC\ STC}$ of the PV strings exceeds 120 V DC.

The PV array junction box, PV generator junction box and switchgear assemblies shall be in compliance with SASO 1609.

712:51-2 Operational conditions and external influences

712:51-2.1.1 Electrical equipment on the DC side shall be suitable for direct voltage and direct current.

PV modules may be connected in series up to the maximum allowed operating voltage of the PV modules and the PV inverter, whichever is lower. Specifications for this equipment shall be obtained from the equipment manufacturer.

If blocking diodes are used, their reverse voltage shall be rated for 2 x $U_{OC\ STC}$ of the PV string. The blocking diodes shall be connected in series with the PV strings.

712:51-2.2.1 As specified by the manufacturer, the PV modules shall be installed in such a way that there is adequate heat dissipation under conditions of maximum solar radiation for the site.

712:52 Wiring systems

712:52-2 Selection and erection in relation to external influences

712:52-2.8.1 PV string cables, PV array cables and PV DC main cables shall be selected and erected so as to minimize the risk of earth faults and short-circuits.

NOTE This may be achieved for example by reinforcing the protection of the wiring against external influences by the use of single-core sheathed cables.

712:52-2.8.3 Wiring systems shall withstand the expected external influences such as wind, ice formation, temperature and solar radiation.

712:53 Isolation, switching and control

712:53-6 Isolation and switching

712:53-6.2 Isolation

712:53-6.2.1.1 To allow maintenance of the PV inverter, means of isolating the PV inverter from the DC side and the AC side shall be provided.

NOTE Further requirements with regard to the isolation of a PV installation operating in parallel with the public supply system are given in 55-1.7 of Chapter 55.

712:53-6.2.2 Devices for isolation

712:53-6.2.2.1 In the selection and erection of devices for isolation and switching to be installed between the PV installation and the public supply, the public supply shall be considered the source and the PV installation shall be considered the load.

712:53-6.2.2.5 A switch disconnector shall be provided on the DC side of the PV inverter.

712:53-6.2.2.5.1 All junction boxes (PV generator and PV array boxes) shall carry a warning label indicating that active parts inside the boxes may still be live after isolation from the PV inverter.

712:54 Earthing arrangements, protective conductors and protective bonding conductors

Where protective equipotential bonding conductors are installed, they shall be parallel to and in close contact as possible with DC cables and AC cables and accessories.

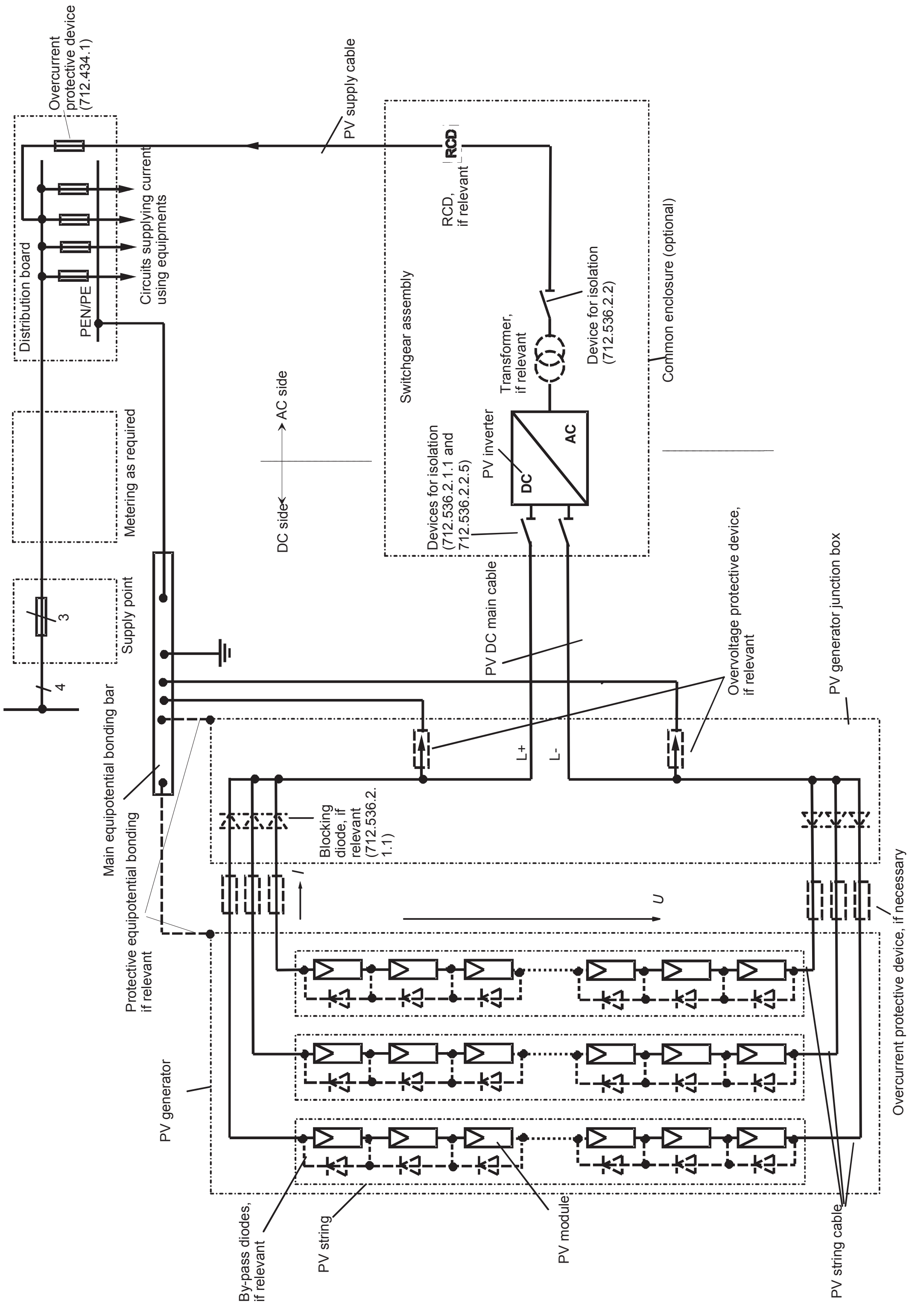


Figure 712-1 PV installation – General schema – One array

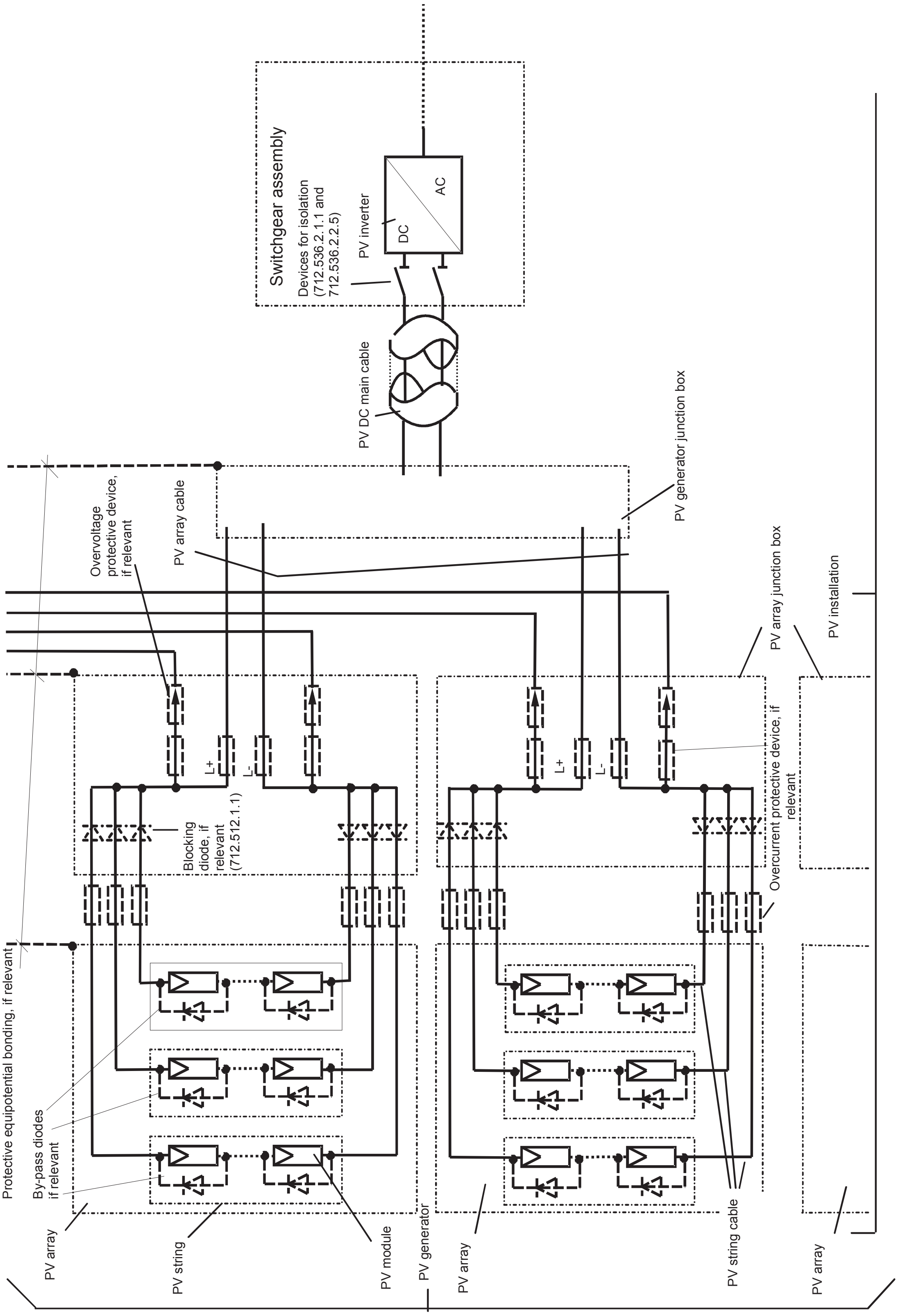


Figure 712-2 PV installation – Example with several arrays

CHAPTER 713
FURNITURE

713:11 Scope

The particular requirements of this chapter apply to the wiring system of furniture (and similar fitments), which is connected to the electrical installation.

Examples are beds, cupboards, desks and shop display cases, in which electrical equipment such as luminaries, socket-outlets, switching devices and wiring systems are installed.

The requirements of this chapter apply to furniture connected by fixed wiring to the electrical installation of the building and also to prefabricated furniture and furniture connected by means of a plug and socket-outlet unless these items are the subject of relevant SASO standards.

Electrical equipment of furniture shall be connected to a single-phase supply $\leq$240 V, and the total load current shall not exceed 16 A.

These requirements do not apply to electrical and equipment specifically designed for installation in furniture and which are the subject of relevant SASO standards, for example radios, TV receivers, refrigerators and laboratory tables, installed in the furniture and ready for connection to the electrical installations of buildings via plugs and socket-outlets. For special locations, other specific requirements may apply, for example see Chapters 701 and 707.

713:51 Common rules

Electrical equipment and accessories for the wiring system of furniture shall be selected and erected in accordance with the environmental situation, in particular mechanical stress and fire risk.

713:52 Wiring systems

713:52-0.1 Connection between the fixed installation of buildings and furniture

The connection between the fixed installation of a building and the wiring system of furniture shall be a fixed connection or plug and socket-outlet connection.

713:52-0.2 Selection of wiring system

The wiring system for connecting the furniture to electrical installations shall be:

- Rigid cable according to SASO IEC 60502, SASO 1320 or SASO 595, if connected by fixed wiring;
- Rubber-insulated flexible cables and cords according to SASO 598; or
- PVC-insulated flexible cables and cords according to SASO IEC 60227-5 if connected by means of a plug and socket-outlet.

Any wiring within the furniture, which may be subject to movement, shall be a flexible cable or cord according to SASO 598 or SASO 1321.

713:52-0.3 Cross-sectional area of conductors

Conductors shall be of copper and have a cross-sectional area of not less than 1.5 mm^2.

The cross-sectional area of flexible cables and cords may be reduced to 0.75 mm^2 copper provided that they do not feed a socket-outlet and their length does not exceed 10 m.

713:52-0.4 Methods for erection of wiring system

Cables and cords shall be suitably protected against damage. They shall be securely fixed to the furniture or located in cable ducting, cable trunking, conduit or a channel formed during the construction of the furniture.

Cables and cords shall be protected against tension or torsion. Strain relief devices shall be provided at points of entry into the furniture and in proximity to connections.

713:52-0.5 Selection of accessories

The accessories for the wiring system shall fulfill the requirements for hollow wall boxes according to SASO IEC 60670. This include the following:

- high mechanical strength;
- accessories shall be fixed to the furniture;
- thermal resistance according to SASO IEC 60695-2-11 (850°C concerning the glow-wire test);
- protection against ingress of solid foreign objects IP3X, according to SASO 980.

713:55 Other equipment

713:55-0.1 Luminaires and other electrical equipment

Luminaires and other equipment shall be selected and erected in compliance with 713:55-1.1 to 713:55-1.3.

713:55-0.1.1 The maximum temperature attained by luminaire housing and other equipment shall not exceed the following values:

- in normal operation 90°C; and
- in case of a fault 115°C.

Furthermore, the instructions of the manufacturer shall be applied concerning the fitting position and the safety distances to inflammable parts.

713:55-0.1.2 On or beneath luminaires in furniture, the maximum permissible wattage for the lamp shall be marked, if the construction of the luminaires does not prevent the fitting of a lamp of higher wattage.

713:55-0.1.3 Where the power dissipated by electrical equipment is liable to produce temperatures within a closed space which may lead to a fire, a switch controlled by the closing of the door shall be installed in such manner that the equipment is reliably switched off when the door is closed. This is the case, for example, for luminaires installed in a foldaway bed.

CHAPTER 714
EXTERNAL LIGHTING INSTALLATIONS

714:11 Scope

This Chapter deals with fixed external lighting installations.

NOTE External lighting comprises luminaires, wiring system and accessories located outside buildings.

The requirements apply particularly to:

- lighting installations e.g. for roads, parks, gardens, public places, sporting areas, illumination of monuments and floodlighting;
- other installations incorporating lighting such as telephone kiosks, bus shelters, advertising panels, town plans, roads signs.

These rules do not apply to:

- public lighting installations which are part of public power grid and operated by a public supply authority who is responsible for and has taken all necessary measures regarding safety;
- temporary festoon lighting;
- road traffic signal systems;
- luminaries which are fixed to the outside of a building and are supplied directly from the internal wiring of that building.

For lighting installations for swimming pools and fountains, see Chapter 702.

714:32 Classification of external influences

Classes of external influences for ambient temperature and climatic conditions depend on local conditions. The following classes are generally recommended:

- ambient temperature: AA4 and AA6 (from –5°C to +60°C);
- climatic conditions: AB4 and AB6 (relative humidity between 5 % and 100 %);

The classes given for the following external influences are minimum requirements:

- presence of water: AD4 (splashes);
- presence of foreign bodies: AE4 (dust).

Classes of other conditions of external influences are dependant on local conditions.

NOTE Other classes of external influences, e.g. corrosive substances, mechanical impact, solar radiation, etc. may be applicable in certain conditions (see Chapter 51).

714:41 Protection against electric shock

714:41-2 Protection against direct contact

All live parts of electrical equipment shall be protected by insulation or by barriers or enclosures preventing direct contact, unintentional or not.

Cabinets housing accessible live parts shall be locked with a key or a tool, unless they are in a location where only skilled or instructed persons may obtain access.

Doors giving access to electrical equipment and located less than 2.50 m above earth level shall be locked with a key or a tool. In addition protection against direct contact shall be provided when the door is open either by the use of equipment having at least the degree of protection IP2X or IPXXB

by construction or by installation, or by placing a barrier or an enclosure giving the same degree of protection.

For luminaries at height less than 2.80 m above earth level, access to the light source shall only be possible after removing a barrier or an enclosure requiring the use of a tool.

714:41-3 Protection against indirect contact

Protection by non-conducting location and protection by earth-free local equipotential bonding shall not be used.

714:41-3.1 Protection by automatic disconnection of supply

Metallic structures (such as fences, grids etc.), which are in the proximity of but are not part of the external lighting installation, need not be connected to the earthing terminal.

In the case of a TT-system with an earth electrode of sufficiently low resistance, protection by disconnection by fuses or circuit breakers is preferred. The use of a single residual current protective device at the origin of the installation is not recommended in case of a single fault in one lighting equipment can cause the disconnection of the whole lighting installation and may create safety risks for the users.

It is recommended that installations incorporating lighting such as defined in the second indent of 714:11 is protected by a residual current protective device having a rated operating residual current not exceeding 30 mA, the lighting of such equipment being less important from the point of view of the safety of persons; furthermore, such protective devices provide supplementary protection against direct contact.

714:41-3.2 Protection by use of class II equipment or by equivalent insulation

NOTE It is considered that the requirements for protection by use of class II equipment are met if the metal covering, if any, of the wiring system is separated from the conductive parts of the lighting column by the use of insulating material, e.g. sleeves or tubes.

No protective conductor shall be provided and the conductive parts of the lighting column shall not be intentionally earthed.

714:51 Common rules

Electrical equipment shall have, by construction or by installation, at least the degrees of protection IP54.

NOTE It may be necessary in some cases, due to operational or cleaning conditions, to require higher degrees of protection.

For luminaries, the degree of protection at least IP54 are required according to the external influences as classified above.

Construction and safety requirements of luminaires are given in SASO 1318.

714:51-1 Impact

Ducting, marker tape or cable tiles used with external lighting supply cable shall be suitably colour coded or marked for the purpose of identification and shall be distinct from other services.

714:51-2 Voltage drop

The voltage drop in normal service shall be compatible with the conditions arising from the starting current of the lamps.

CHAPTER 715
EXTRA-LOW-VOLTAGE LIGHTING INSTALLATIONS

715:11 Scope

The particular requirements of this chapter apply to extra-low-voltage lighting installations supplied from sources with a maximum rated voltage of 50V a.c. or 120V d.c.

NOTE 1 For the definition of an extra-low-voltage lighting system reference should be made to SASO 1318 and SASO 1689.

NOTE 2 AC voltages are given as r.m.s. values.

715:41 Protection against electric shock

715:41-1 Protection against both direct and indirect contact

715:41-1.1 For extra-low-voltage lighting installations only SELV shall be applied. Where bare conductors are used (see 715:52-1.7), the maximum voltage shall be 25 V a.c. or 60 V d.c. according to 41-1.1.4.3 of Chapter 41.

715:41-1.2 Safety isolating transformers shall conform with SASO IEC 61558-2-6.
The SELV sources shall be fixed and not mobile.
Parallel operation of transformers in the secondary circuit is allowed only if they are also paralleled in the primary circuit and the transformers have identical electrical characteristics.

715:42 Protection against thermal effects

715:42-2 Measures for protection against fire

715:42-2.3 Nature of processed or stored materials

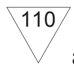
The manufacturer's installation instructions shall be followed, including those relating to mounting on flammable or non-flammable surfaces. See also 55-9.

715:42-2.5 Fire risk of transformers/converters

715:42-2.5.1 Transformers shall be either:

- protected on the primary side by the protective device required in 715:42-2.6.2; or
- short-circuit proof transformers (both inherently and non-inherently proof), see Annex A.715 for marking.

715:42-2.5.2 Electronic converters shall comply with SASO IEC 61347, and with the requirements of SASO 1689.

NOTE It is recommended that converters marked with the symbol 

are used. See Annex A.715 for the symbol.

715:42-2.6 Fire risk by short-circuit

715:42-2.6.1 If both circuit conductors are uninsulated, they shall be either:

- provided with a special protective device complying with the requirements of 715:42-2.6.2; or
- supplied from a transformer complying with SASO IEC 61558-2-6, or a converter, the power of which does not exceed 200 VA; or
- systems complying with SASO 1689.

715:42-2.6.2 The special protective device against the risk of fire shall comply with the following requirements:

- continuous monitoring of the power demand of the luminaires;
- automatic disconnection of the supply circuit within 0.3 s in case of a short-circuit or failure which causes a power increase of more than 60 W;
- automatic disconnection while the supply circuit is operating with reduced power (for example by gating control or a regulating process or a lamp failure) if there is a failure which causes a power increase of more than 60 W;
- automatic disconnection, in the case of switching on the supply circuit if there is a failure which causes a power increase of more than 60 W;
- the special protective device shall be fail safe.

715:43 **Protection against overcurrent**

715:43-0 The SELV circuit shall be protected against overcurrent either by a common protective device or a protective device for each SELV circuit, in accordance with the requirements of Chapter 43.

NOTE 1 When selecting the protective device for the primary circuit account should be taken of the magnetising current of the transformer.

The overcurrent protective device shall be of the non-self-resetting type.

NOTE 2 Overcurrent protection may be provided by a protective device complying with the requirements of 715:42-2.6.2.

715:52 **Wiring systems**

715:52-1 **Types of wiring systems**

715:52-1.1.1 The following wiring systems shall be used:

- insulated conductors in conduit or cable trunking;
- cables;
- flexible cables or cords;
- systems for extra-low-voltage lighting according to SASO 1318;
- track systems according to SASO 1670.

Where parts of the extra-low-voltage lighting installation are accessible, the requirements of 42-3 of Chapter 42 apply.

Metallic structural parts of buildings, for example, pipe systems or parts of furniture shall not be used as live conductors.

715:52-1.7 **Bare conductors**

If the nominal voltage does not exceed 25 V a.c. or 60 V d.c bare conductors may be used provided that the extra-low-voltage lighting installation complies with the following requirements:

- the lighting installation is designed, installed or enclosed in such a way that the risk of a short-circuit is reduced to a minimum; and
- the conductors used have a cross-sectional area of at least 4 mm^2, for mechanical reasons; and
- the conductors or wires are not placed directly on combustible material.

For suspended bare conductors at least one conductor and its terminals shall be insulated, for that part of the circuit between the transformer and the protective device, to prevent a short-circuit.

715:52-1.8 Suspended systems

Suspension devices for luminaires, including supporting conductors, shall be capable of carrying five times the mass of the luminaire intended to be supported, but not less than 10 kg.

Terminations and connections of conductors shall be made by screw terminals or screwless clamping devices complying with SASO IEC 60998-2-1.

Insulation piercing connectors and termination wires, with counterweights, hung over suspended conductors shall not be used.

The suspended system shall be fixed to walls or ceilings by insulated distance cleats and shall be continuously accessible throughout the route.

715:52-1.9 Track systems for luminaires

Track systems for luminaires shall comply with the requirements of SASO 1670.

715:52-3 Current-carrying capacities

Values of current-carrying capacity for uninsulated conductors are under consideration.

715:52-4 Cross-sectional areas of conductors

715:52-4.1 The minimum cross-sectional area of the extra-low-voltage conductors shall be:

- 1,5 mm^2 copper for the wiring systems mentioned above, but in the case of flexible cables with a maximum length of 3 m a cross-sectional area of 1 mm^2, copper may be used;
- 4 mm^2 copper in the case of suspended flexible cables or insulated conductors, for mechanical reasons.

715:52-5 Voltage drop in consumers' installations

715:52-5.1 In extra-low-voltage lighting installations particular attention shall be given to the voltage drop requirements.

715:53 Isolation, switching and control

715:53-6 Isolation and switching

Where transformers are operated in parallel the primary circuit shall be permanently connected to a common isolating device.

715:55 Other equipment

Luminaires complying with SASO 1318 shall be used.

Protective devices in the extra-low-voltage circuit shall be integral with the current source or shall be fixed.

Protective devices shall be easily accessible.

Protective devices may be located above false ceilings, which are moveable or easily accessible, provided that information is given about the presence and location of the device.

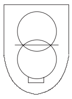
If the identification of a protective device for a circuit is not immediately visible, a sign or diagram (label) close to the protective device shall identify the circuit and its purpose.

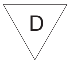
Transformers, protective devices or similar equipment mounted above false ceilings or in a similar place shall be mounted on a fixed part and permanently connected.

Annex A.715

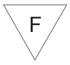
(informative)

Provisional Explanation of the Symbols Used in this Chapter

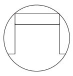

Short-circuit proof (inherently or non-inherently) safety isolating transformer SASO IEC 61558-2-6

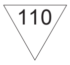


Luminaire with limited surface temperature



luminaire suitable for direct mounting on normally flammable surfaces SASO 1318


Independent ballast, SASO IEC 60417 symbol No. 5138



Converter with a temperature limitation of 110°C

CHAPTER 717
MOBILE OR TRANSPORTABLE UNITS

717:11 **Scope**

The particular requirements as specified in this chapter are applicable to mobile or transportable units.

For the purpose of this chapter, the term “unit” is intended to mean a vehicle and/or mobile or transportable structure in which all or part of an electrical installation is contained.

Units are:

- either of the mobile type, e.g. vehicles (self-propelled or towed);
- or of the transportable type, e.g. containers or cabins placed on a base frame.

Examples of the intended use are for broadcasting, medical services, advertising, fire fighting, workshops, etc.

Two or more units may be electrically connected together.

The requirements are not applicable to:

- generating sets;
- marinas and pleasure craft;
- mobile machinery in accordance with SASO IEC 60204-1;
- caravans;
- traction equipment of electric vehicles.

Where applicable, additional requirements as laid down in other chapters of special installations or locations are to be taken into consideration, e.g. for showers, medical locations, etc.

717:31 **Purposes, supplies and structures**

717:31-2 **Types of distribution systems**

717:31-2.2 **Types of earthing system**

NOTE Where the designation TN or TT or IT is used in this chapter, it means only that the protective principles of these systems apply.

717:31-2.2.1 **TN System**

The use of the TN-C system is not permitted inside any unit.

717:31-3 **Supplies**

The following methods can be used to supply a unit:

a) connection to a low-voltage generating set in accordance with 55-1 of Chapter 55 (see Figures 717-1.1 and 717-1.2), or

b) connection to a fixed electrical installation in which the protective measures are effective (see Figures 717-2.1 and 717-2.2), or

c) connection through means providing simple separation, in accordance with SASO IEC 61140, from a fixed electrical installation (see Figures 717-3.1, 717-3.2 and 717-3.3), or

d) connection through means providing electrical separation from a fixed electrical installation (see example in Figure 717-4).

NOTE 1 In cases a), b) and c), an earth electrode may be provided.

NOTE 2 In the case of Figure 717-3.1, an earth electrode may be necessary for protective purposes (see 717:41-3.1.5.3).

NOTE 3 Simple separation or electrical separation is appropriate, for example when information technology equipment is used in the unit or when reduction of electromagnetic influences is necessary.

A unit may be supplied by any method in accordance with a), b), c), or d), or by the method a) combined with one of the other methods.
The sources, means of connection or separation may be within the unit.

717:41 **Protection against electric shock**

717:41-2 **Protection against direct contact**

717:41-2.4 Protection by placing out of reach is not permitted.

717:41-2.5 Additional protection by residual current protective devices with a rated residual operating current not exceeding 30 mA is necessary for all socket-outlets intended to supply current-using equipment outside the unit, with the exception of socket-outlets which are supplied from circuits with protection by:

- SELV, or
- PELV, or
- electrical separation.

717:41-3 **Protection against indirect contact**

717:41-3.1 **Protection by automatic disconnection of supply**

a) For supply in accordance with 717:31-3 a), only TN and IT systems are permitted and protection shall be provided by automatic disconnection of supply, and:
- in a TN system, 717:41-3.1.3 applies;
- in an IT system, 717:41-3.1.5 applies.

b) For supply in accordance with 717:31-3 b), only TN and TT systems are permitted and automatic disconnection of the supply shall be provided by a residual current protective device, with a rated residual current not exceeding 30 mA. This is not required for circuits inside units having a non-conductive enclosure where protection by earth-free local equipotential bonding is applied (see Figure 717-2.2).

c) In all cases a) to d) of 717:31-3, any equipment installed between the source of supply and the protective devices providing the automatic disconnection of the supply within the unit, including these protective devices themselves, shall be protected by use of Class II equipment or by equivalent insulation.

717:41-3.1.2 **Equipotential bonding**

717:41-3.1.2.1 **Main equipotential bonding**

Accessible conductive parts of the unit, such as chassis, body structure or tube systems, shall be interconnected and, through the main equipotential bonding conductors, connected to the protective conductor of the TT, IT or TN systems within the unit.
The main equipotential bonding conductor shall be finely stranded. Type 227 IEC 02 in accordance with SASO 1320 is appropriate.

717:41-3.1.3 **TN system**

717:41-3.1.3.1 In the case of use of the TN system in units with a conductive enclosure and supplied according to 717:31-3 a) or c), this enclosure shall be connected to the neutral point or, if not available, a phase conductor (see Figures 717-1.1, 717-1.2 and 717-3.3).

In the case of use of the TN system in a unit without a conductive enclosure, the exposed conductive parts of the equipment inside the unit shall be connected by means of a protective conductor to the neutral point or, if not available, to a live conductor.

717:41-3.1.5 IT system

717:41-3.1.5.3 In the case of use of the IT system in units with a conductive enclosure, a connection of the exposed conductive parts of the equipment to the conductive enclosure is necessary.

In the case of units without a conductive enclosure, the exposed conductive parts inside shall be connected to one another and to a protective conductor.

An IT system can be provided by:

a) an isolating transformer or a low-voltage generating set, with an insulation monitoring device installed;

b) a transformer providing simple separation, e.g. in accordance with SASO IEC 61558-1 only in the following cases:

- an insulation monitoring device is installed with or without an earth electrode, providing automatic disconnection of the supply in case of a first fault between live parts and the frame of the unit (see Figure 717-3.2), or
- a residual current device and an earth electrode are installed to provide automatic disconnection in the case of failure in the transformer providing the simple separation (see Figure 717-3.1). Each equipment used outside the unit shall be protected by a separate residual current protective device with rated residual current not exceeding 30 mA.

717:41-3.5 Protection by electrical separation

(See Figure 717-4.)

717:43 Protection against overcurrent

717:43-1 Requirements according to the nature of the circuits

717:43-1.1 In the case where the supply is in accordance with 717:31-3 a) or c), and where a line conductor is connected to the conductive enclosure of the unit, no overcurrent protective device is required in this line conductor which is connected to the conductive enclosure of the unit.

717:51 Common rules

717:51-4 Identification

717:51-4.1 A plate shall be affixed on the outside adjacent to the feeder assembly entrance or at a location which is clearly visible to the user of the unit, stating in clear and unambiguous terms the types of supply which may be connected to the unit including the supply voltage and the correct ampere rating. The descriptions set out in 717:31-3 shall be used.

717:51-4.4 Protective devices

Electrical distribution panelboards containing circuit breakers shall be dead-front type. Where plug fuses and fuseholders are used, they shall also

be enclosed in dead-front fuse panelboards. The distribution panelboard shall be located in a suitable accessible location with a clear working space.

717:52 Wiring systems

717:52-1 Types of wiring systems

717:52-1.7 Cables type 245 according to SASO 598 or cables of equivalent design having a minimum cross-sectional area of 2.5 mm² Cu shall be used for connecting the unit to the supply. The flexible cable shall enter the unit by an insulating inlet in such a way as to minimize the possibility of any insulation damage or fault which might energize the exposed conductive parts of the unit. The cable sheath shall be firmly gripped or anchored to the unit.

717:52-1.8 The flexible cable shall be a feeder assembly with an integrally molded or securely attached plug cap, or a permanently installed feeder. Flexible cables with adapters, extension cords and similar items shall not be attached to the unit.

717:52-1.9 The following or other equivalent cable types are permitted for the internal wiring of the unit:

a) PVC insulated single-core cable in accordance with SASO 1320 or laid in conduits in accordance with SASO 254 and SASO 255;

b) PVC insulated sheathed cables in accordance with SASO 1450 or sheathed cables type 245 in accordance with SASO 598, if precautionary measures are taken that no mechanical damage is likely to occur due to the sharp-edged parts or abrasion.

The requirements of this subsection do not apply to information technology equipment.

717:55 Other equipment

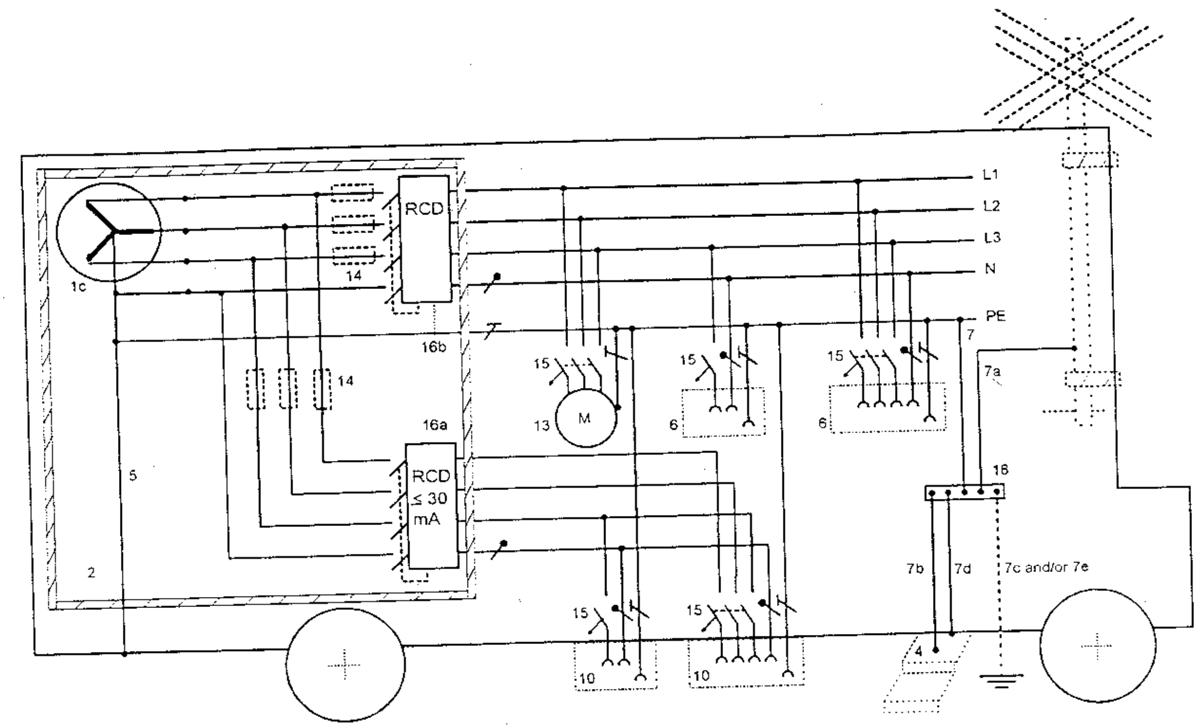
717:55-0.1 Plugs and socket-outlets shall comply with SASO 1693 or SASO IEC 60884-1.

Permanent provisions shall be made for the protection of the attachment plug cap of the power-supply flexible cable and any connector cord assembly or receptacle against corrosion and mechanical damage if such devices are in an exterior location while the unit is in transit.

Connecting devices used to connect the unit to the supply shall comply with SASO IEC 60309-2 and with the following requirements:

- plugs shall have an enclosure of insulating material;
- plugs and socket-outlets shall afford a degree of protection of not less than IP44, if located outside;
- appliance inlets with their enclosures shall provide a degree of protection of at least IP55;
- the plug part shall be situated on the unit.

717:55-0.2 Socket-outlets located outside the unit shall be provided with an enclosure affording a degree of protection not less than IP54.



NOTE Protection by automatic disconnection of supply by residual current protective devices (RCD).

Figure 717-1.1 Example of connection to a Class I or Class II low-voltage generating set located inside the unit with or without an earth electrode

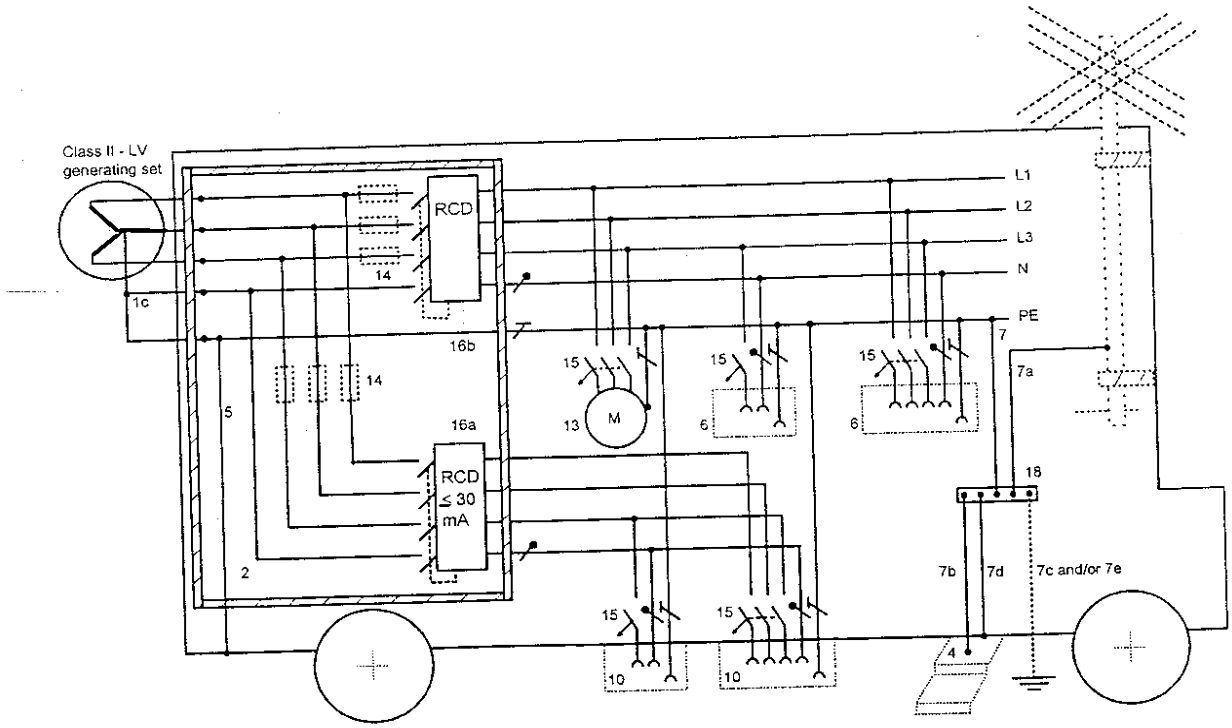


Figure 717-1.2 Example of connection to a Class II low-voltage generating set located outside the unit

Key to figures 717-1.1 and 717-1.2

1c Connection to a LV generator set in accordance with 55-1

2 Class II or equivalent enclosure up to the first protective device providing automatic disconnection of supply

4 Conductive staircase, if any

5 Connection of the neutral point (or, if not available, a phase conductor) to the conductive structure of the unit

6 Socket-outlets for use exclusively within the unit

7 Main equipotential bonding in accordance with 717:41-3.1.2.1

7a to an antenna pole, if any

7b to the conductive external stairs, if any, in contact with the earth

7c to a functional earth electrode (in case of need)

7d to the conductive enclosure of the unit

7e to an earth electrode for protective purposes, if any

10 Socket-outlets for current-using equipment for use outside the unit

13 Current-using equipment for use within the unit

14 Overcurrent protective device, if required

15 Overcurrent protective device (e.g. a circuit-breaker)

16a Residual current protective device rated with a rated residual operating current not exceeding 30 mA for protection by automatic disconnection of supply for circuits of equipment for use outside the unit

16b Residual current protective device for protection by automatic disconnection of supply for circuits of equipment for use inside the unit

18 Main earthing terminal or bar

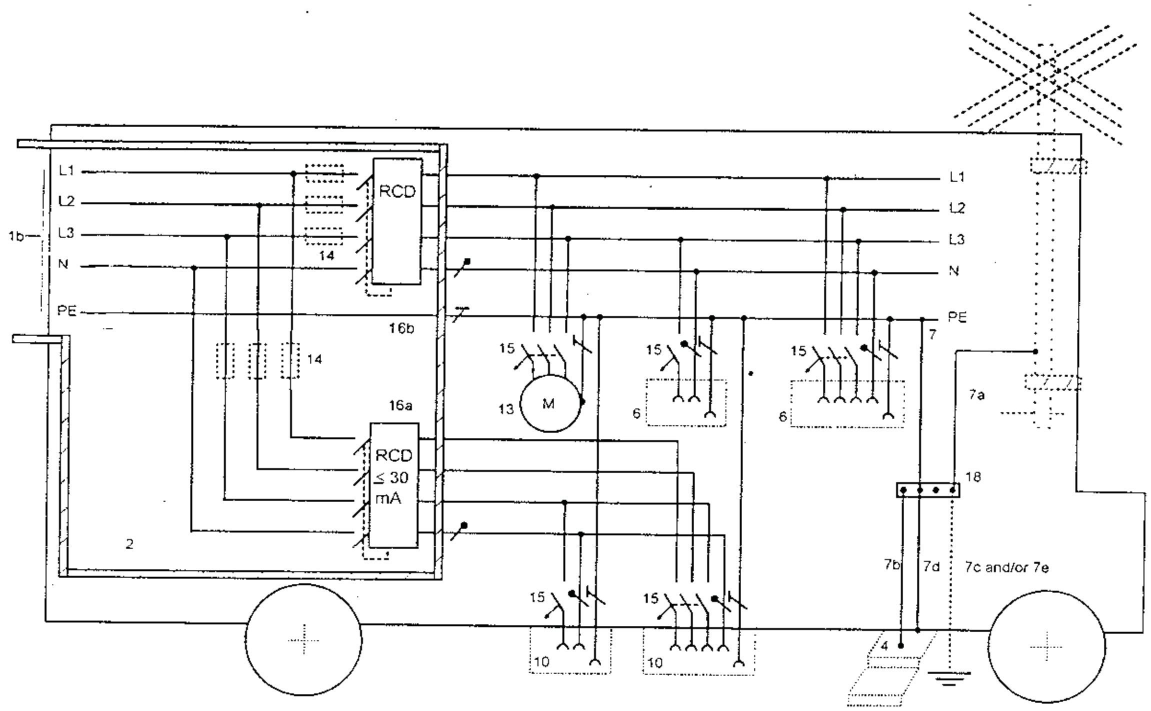


Figure 717-2.1 Example of connection to any type of earthing system of a fixed installation with automatic disconnection of supply by residual current device (RCD) with or without an earth electrode

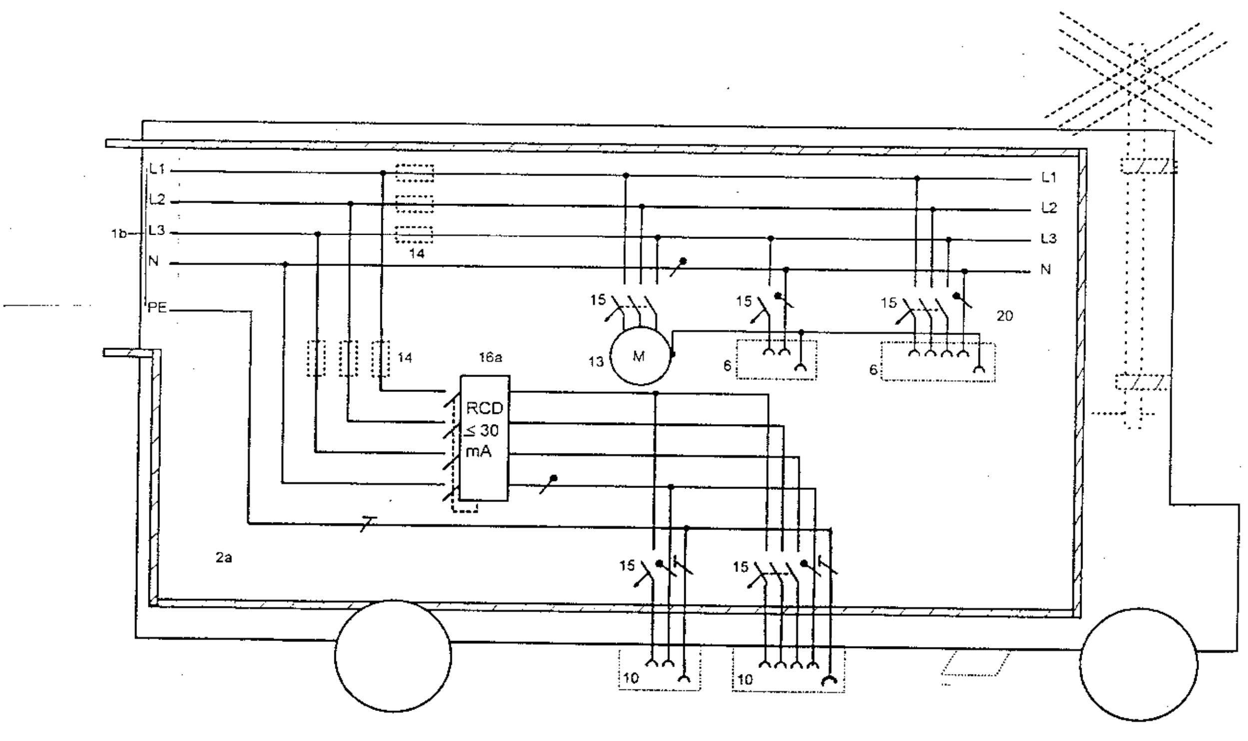


Figure 717-2.2 Same example with protection by earth free local equipotential bonding with a non-conductive enclosure within the unit

Key to figures 717-2.1 et 717-2.2

1b Connection of the unit to a supply in which the protective measures are effective

2 Class II or equivalent enclosure up to the first protective device providing automatic disconnection of supply

2a Non-conductive environment

4 Conductive staircase, if any

6 Socket-outlets used exclusively within the unit

7 Main equipotential bonding in accordance with 717:41-3.1.2.1

7a to an antenna pole, if any

7b to the conductive external stairs, if any, in contact with the earth

7c to a functional earth electrode (in case of need)

7d to the conductive enclosure of the unit

7e to an earth electrode, for protective purposes, if any

10 Socket-outlets for current-using equipment for use outside the unit

13 Current-using equipment for use exclusively within the unit

14 Overcurrent protective device, if required

15 Overcurrent protective device (e.g. one P or PN circuit-breaker)

16a Residual current protective device rated with a rated residual operating current not exceeding 30 mA for protection by automatic disconnection of supply for circuits of equipment for use outside the unit

16b Residual current device for protection by automatic disconnection of supply

18 Main earthing terminal or bar

20 Earth-free local equipotential bonding in accordance with 41-3.4

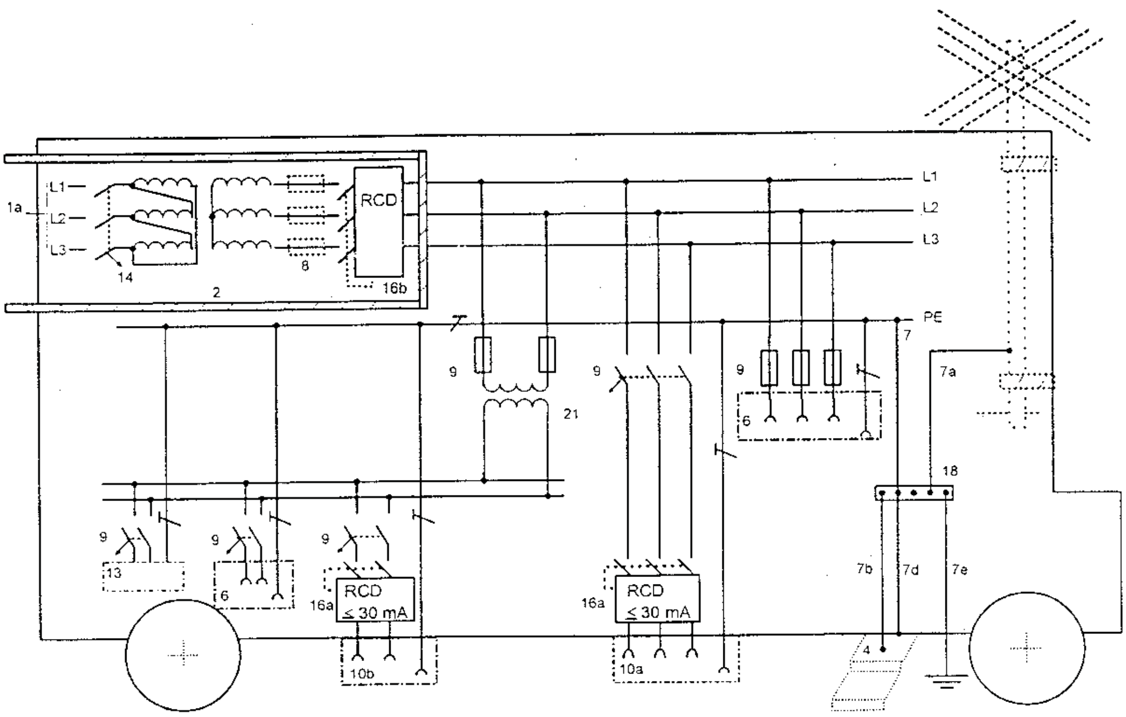


Figure 717-3.1 Example of connection to a fixed electrical installation with any type of earthing system using a simple separation transformer and an IT system with an earth electrode

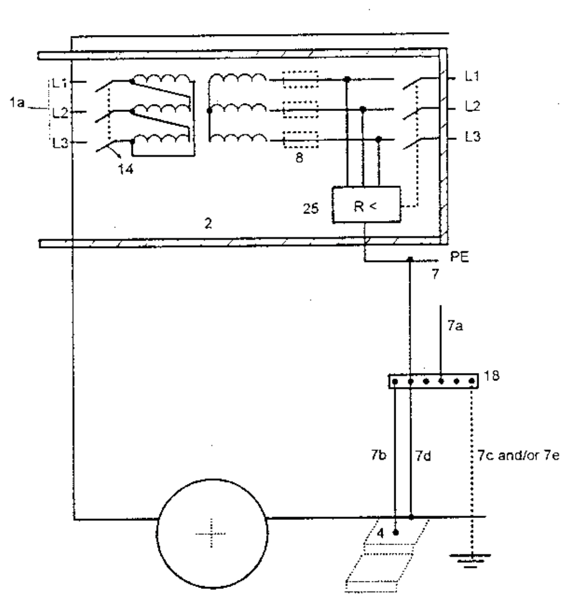


Figure 717-3.2 Example of connection with simple separation and an IT system with an insulation monitoring device and disconnection of supply after a first fault, with or without an earth electrode

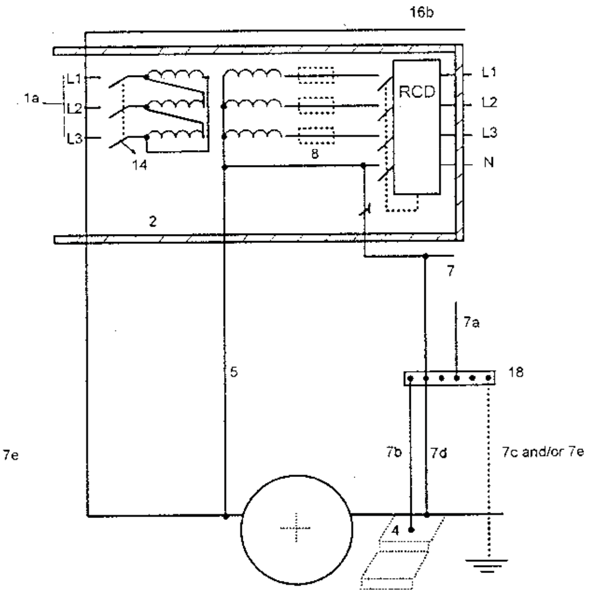


Figure 717-3.3 Example of connection with simple separation and a TN system with or without an earth electrode

Key to figures 717-3.1, 717-3.2 and 717-3.3

1a Connection of the unit to a supply through a transformer with simple separation in accordance with 717:31-3 c)

2 Class II or equivalent enclosure up to the first protective device (see item 8 or 9) providing automatic disconnection of supply

4 Conductive staircase, if any

5 Connection of the neutral point (or, if not available, a phase conductor) to the conductive structure of the unit

6 Socket-outlets for use exclusively within the unit

7 Main equipotential bonding in accordance with 717:41-3.1.2.1

7a to an antenna pole, if any

7b to the conductive external stairs, if any, in contact with the earth

7c to a functional earth electrode (in case of need)

7d to the conductive enclosure of the unit

7e to an earth electrode, for protective purposes, if any

8 Protective devices, if required, for overcurrent and/or for protection by disconnection of supply in case of a second fault

9 Protective devices for overcurrent and for automatic disconnection of supply in case of a second fault

10a Three-phase socket-outlet for current-using equipment outside the unit

10b Single-phase socket-outlet for current-using equipment outside the unit

13 Current-using equipment used exclusively within the unit

14 Overcurrent protective device, if required

16a Residual current protective device rated with a rated residual operating current not exceeding 30 mA for protection by automatic disconnection of supply for circuits of equipment for use outside the unit

16b Residual current device for protection by automatic disconnection of supply

18 Main earthing terminal or bar

21 Transformer for e.g. 230 V current-using equipment

25 Insulation monitoring device

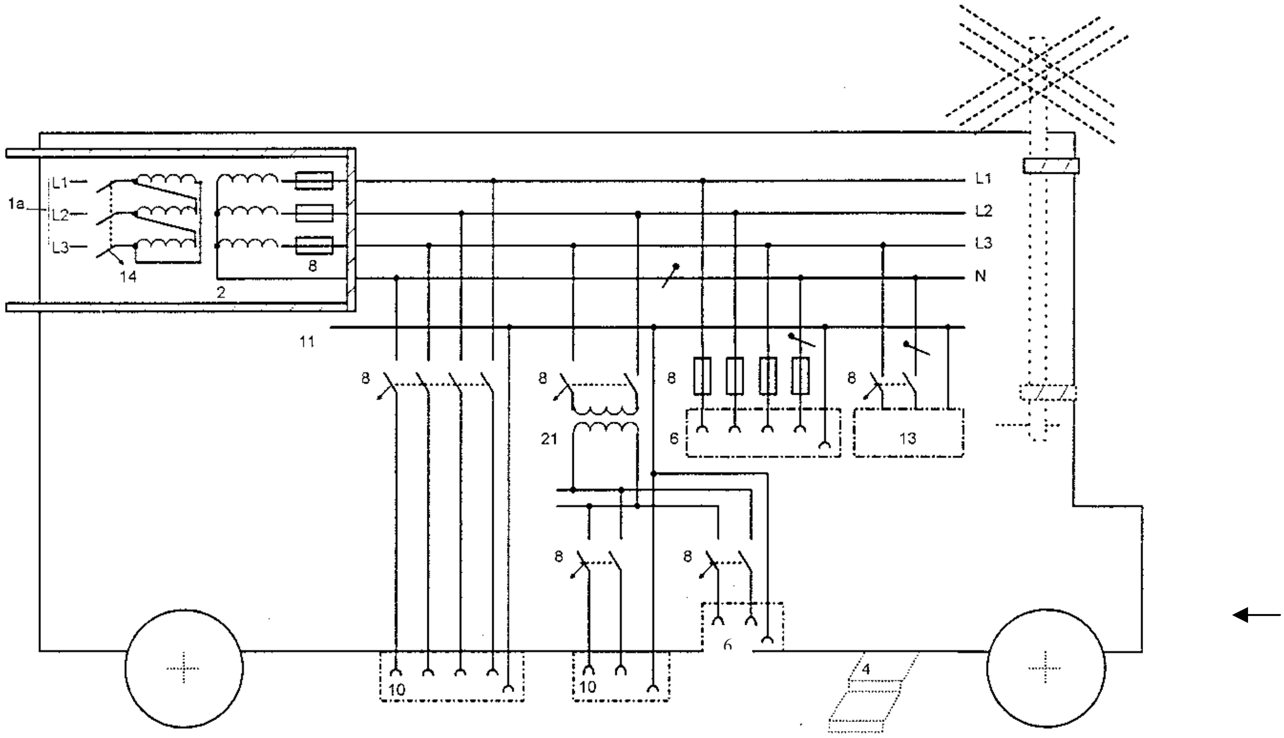


Figure 717-4 Example of connection to a fixed electrical installation with any type of earthing system using an electrical separation provided by an isolating transformer

Key to figure 717-4

1a Connection of the unit to a supply through a transformer providing electrical separation

2 Class II or equivalent enclosure up to the first protective device providing automatic disconnection of supply

4 Conductive staircase, if any

6 Socket-outlets for use exclusively within the unit

8 Protective devices for automatic disconnection of supply in case of a second fault and, if required, against overcurrent

10 Socket-outlets for current-using equipment outside the unit

11 Insulated non-earthed equipotential bonding in accordance with 41-3.5.3.1

13 Current-using equipment for use within the unit

14 Overcurrent protective device, if required

21 Transformer for e.g. 230 V current-using equipment

CHAPTER 720
ELECTRICAL INSTALLATIONS IN HAZARDOUS LOCATIONS – GENERAL REQUIREMENTS

720-1 Introduction

When electrical equipment is to be installed in locations where dangerous concentrations and quantities of flammable gases, vapours, mists, ignitable fibres or dusts may be present in the atmosphere, protective measures are applied to reduce the likelihood of explosion due to ignition by arcs, sparks or hot surfaces, produced either in normal operation or under specified fault conditions. This chapter is supplementary to other relevant chapters of these Electrical Requirements as regards to electrical installation requirements.

By careful design of the electrical installation, it is frequently possible to locate most of the electrical equipment in non-hazardous or less hazardous locations.

Inspection, maintenance and repair aspects also form an important part of hazardous location installations and the user's attention is drawn to SASO IEC 60079-17 and SASO IEC 60079-19 for further information concerning these aspects.

This chapter covers the general requirements for electrical installations in hazardous locations. Chapters 721 through 725 contain the additional requirements for particular types of protection.

720:11 Scope

This Chapter contains special requirements for the selection and erection of electrical installations in hazardous locations.

These requirements are in addition to the requirements for installations in non-hazardous locations.

All electrical equipment and wiring in hazardous locations shall be selected and installed in accordance with this chapter. The additional requirements for the particular type of protection are conducted in Chapters 721 to 725 inclusive.

This chapter applies to all electrical equipment installations in hazardous locations whether permanent, temporary, portable, transportable or hand-held.

Equipment and systems used in exceptional circumstances, for example research, development, pilot plant and other new project work, need not meet the requirements of this chapter, provided that the installation is in use for limited periods only, and is under the supervision of specially trained personnel. (see SASO IEC 60079-14).

This chapter does not apply to:

- electrical installations in mines susceptible to firedamp;

  NOTE This chapter may apply to electrical installations in mines where explosive gas atmospheres other than firedamp may be formed and to electrical installations in the surface installation of mines.

- electrical installations in areas where the hazard is due to combustible dusts or fibres; (see SASO IEC 61241-series)
- inherently explosive situations, for example explosives manufacturing and processing;
- rooms used for medical purposes.

720:32 Classification of external influences

720:32-1 Classification of zones

Hazardous locations are divided into Zones 0, 1 and 2 according to SASO IEC 60079-10 as follows:

- **Zone 0**
  place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is present continuously or for long periods or frequently.
- **Zone 1**
  place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is likely to occur in normal operation occasionally.
- **Zone 2**
  place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

720:32-2 Classification of protection types

Most common types of protection of electrical equipment against hazardous locations are as follows:

Flameproof enclosures	"d"	according to SASO IEC 60079-1
Pressurized enclosures	"p"	according to SASO IEC 60079-2
Powder filling	"q"	according to SASO IEC 60079-5
Oil immersion	"o"	according to SASO IEC 60079-6
Increased safety	"e"	according to SASO IEC 60079-7
Intrinsic safety	"i"	according to SASO IEC 60079-11
Encapsulation	"m"	according to SASO IEC 60079-18

720:41 Protection against electric shock

720:41-1 Protection against both direct and indirect contact

720:41-1.1 SELV and PELV systems

720:41-1.1.1 Safety extra-low-voltage systems (SELV) shall be in accordance with 41-1.1.1 to 41-1.1.4 of Chapter 41. Live parts of SELV circuits shall not be connected to earth, or to live parts or to protective conductors forming part of other circuits.

720:41-1.1.2 Protective extra-low-voltages systems (PELV) shall be in accordance with 41-1.1.1 to 41-1.1.3 and 41-1.1.5 of Chapter 41, where the circuits may be earthed or unearthed. If the circuits are earthed, the circuit earth and any exposed conductive parts shall be connected to a common potential equalization system. If the circuits are not earthed, any exposed conductive parts may be earthed (for example for electro-magnetic compatibility) or left unearthed.

720:41-1.1.3 Safety isolating transformers for SELV and PELV shall be in accordance with SASO IEC 61558-2-6.

720:41-3 Protection against indirect contact

720:41-3.1 Protection by automatic disconnection of supply

NOTE The basic principles on which safety depends are the limitation of earth-fault currents (magnitude and/or duration) in frameworks or enclosures and the prevention of elevated potentials on equipotential bonding conductors.

Although it is impracticable to cover all possible systems, the following applies to electrical systems, other than intrinsically safe circuits, for use in Zones 1 and 2 up to 1000 V a.c. /1500 V d.c.

720:41-3.1.2 Equipotential Bonding

720:41-3.1.2.1 Equipotential bonding is required for installations in hazardous locations. For TN, TT and IT systems, all exposed and extraneous conductive parts shall be connected to the equipotential bonding system. The bonding system may include protective conductors, metal conduits, metal cable sheaths, steel wire armouring and metallic parts of structures, but shall not include neutral conductors. Connections shall be secure against self-loosening.

720:41-3.1.2.2 Exposed conductive parts need not be separately connected to the equipotential bonding system if they are firmly secured to and are in metallic contact with structural parts or piping which are connected to the equipotential bonding system.

720:41-3.1.2.3 Extraneous conductive parts which are not part of the structure or of the electrical installation need not be connected to the equipotential bonding system, if there is no danger of voltage displacement, for example frames of doors or windows.

720:41-3.1.2.4 Metallic enclosures of intrinsically safe equipment need not be connected to the equipotential bonding system, unless required by the equipment documentation or to prevent accumulation of static charge.

720:41-3.1.2.5 Installations with cathodic protection shall not be connected to the equipotential bonding system unless the system is specifically designed for this purpose.

NOTE Equipotential Bonding between vehicles and fixed installations may require special arrangements, for example where insulated flanges are used to connect pipelines.

720:41-3.1.3 TN systems

If a type TN power system is used, it shall be type TN-S (with separate neutral N and protective conductor PE) in the hazardous area, i.e. the neutral and the protective conductor shall not be connected together, or combined in a single conductor, in the hazardous area. At any point of transition from TN-C to TN-S, the protective conductor shall be connected to the equipotential bonding system in the non-hazardous area.

720:41-3.1.4 TT systems

If a type TT power system (separate earths for power system and exposed conductive parts) is used in Zone 1, then it shall be protected by a residual current device.

NOTE Where the earth resistivity is high, such a system may not be acceptable.

720:41-3.1.5 IT systems

If a type IT power system (neutral isolated from earth or earthed through an impedance) is used, an insulation monitoring device shall be provided to indicate the first earth fault.

NOTE Supplementary equipotential bonding, may be necessary (see Chapter 41).

720:41-3.5 Electrical separation

Electrical separation shall be in accordance with 41-3.5 of Chapter 41 for the supply of only one item of equipment.

720:42 Protection against thermal effect

720:42-1 Protection against fire

720:42-1.3 In order to avoid the formation of sparks liable to ignite the explosive gas atmosphere, the possible inadvertent contact with bare live parts other than intrinsically safe parts shall be prevented.

720:42-1.7 Static electricity

In the design of electrical installations, steps shall be taken to reduce to a safe level the effects of static electricity.

720:44 Protection against voltage disturbances and electromagnetic disturbances

720:44-3 Protection against overvoltages of atmospheric origin

In the design of electrical installations, steps shall be taken to reduce to a safe level the effects of lightning (see Chapter 802 or SASO IEC 62305).

Sub-subsection 723:54-2.2 gives details of lightning protection requirements for Ex “ia” (intrinsic safety, level of protection "ia") equipment installed in Zone 0.

NOTE For associated equipment suitable for installation in a hazardous area, the symbols for the type of protection shall be enclosed within square brackets, for example, Ex d[ia] IIC T4.

720:44-4.3 Measures against electric and magnetic influences on electrical equipment

In the design of electrical installations, steps shall be taken to reduce to a safe level the effects of electromagnetic radiation.

720:51 Common rules

720:51-0 Selection of electrical equipment (excluding cables and conduits)

720:51-0.1 Specific information

In order to select the appropriate electrical equipment for hazardous locations, the following information is required:

- classification of the hazardous area;
- temperature class or ignition temperature of the gas or vapour involved according to 720:51-0.3;
- where applicable, gas or vapour classification in relation to the group or subgroup of the electrical equipment according to 720:51-0.4;

  NOTE Of the types of protection listed in SASO IEC 60079-0, the equipment subgroup is only required for protection types “d” (flameproof enclosures) and “i” (intrinsic safety). The equipment subgroup is also required for certain equipment with protection types “n” or “o” (oil immersion) (see 720:51-0.4).
- external influences and ambient temperature.

720:51-0.2 Selection according to Zones

720:51-0.2.1 Equipment for use in Zone 0

720:51-0.2.1.1 Electrical equipment and circuits can be used in Zone 0 if they are in accordance with SASO IEC 60079-11 (category “ia” – intrinsic safety) and with the requirements of 725:52.

720:51-0.2.1.2 Equipment that conforms to SASO IEC 60079-26 may also be used in Zone 0.

720:51-0.2.2 Equipment for use in zone 1

Electrical equipment can be used in Zone 1 if it is constructed in accordance with the requirements for Zone 0 or one or more of the following types of protection:

Flameproof enclosures "d", Pressurized enclosures "p", Powder filling "q", Oil immersion "o", Increased safety "e", Intrinsic safety "i", and Encapsulation "m".

720:51-0.2.3 Equipment for use in Zone 2

The following electrical equipment may be installed in Zone 2:

a) electrical equipment for Zone 0 or Zone 1; or

b) electrical equipment designed specifically for Zone 2 (for example type of protection "n" according to SASO IEC 60079-15, or

c) electrical equipment complying with the requirements of a recognized standard for industrial electrical equipment which does not, in normal operation, have ignition-capable hot surfaces; and

1) does not, in normal operation, produce arcs or sparks, or
2) in normal operation produces arcs or sparks, but the values of the electrical parameters (U, I, L and C) in the circuit (including the cables) do not exceed the values specified in SASO IEC 60079-11 with a safety factor of unity. The assessment shall be in accordance with the specification for energy limited equipment and circuits given in SASO IEC 60079-15.

Unless safety is demonstrated by test, a surface is presumed to be ignition-capable if its temperature exceeds the ignition temperature of the explosive gas atmosphere concerned.

This electrical equipment shall be in an enclosure with a degree of protection and mechanical strength at least suitable for non-hazardous locations with a similar environment. It requires no special marking, but it shall be clearly identified, either on the equipment or in the documentation.

In the case of rotating electrical machines, incentive sparking shall not occur during start-up unless precautions are taken to ensure that an explosive gas atmosphere is not present.

720:51-0.3 Selection according to the ignition temperature of the gas or vapour

720:51-0.3.1 The electrical equipment shall be so selected that its maximum surface temperature will not reach the ignition temperature of any gas or vapour which may be present.

720:51-0.3.2 Symbols for the temperature classes which may be marked on the electrical equipment have the meaning indicated in Table 720-1.

720:51-0.3.3 If the marking of the electrical equipment does not include an ambient temperature range, the equipment shall be used only within the temperature range –20°C to +40°C.

720:51-0.3.4 If the marking of the electrical equipment includes an ambient temperature range, the equipment shall only be used within this range.

720:51-0.3.5 Simple equipment used within an intrinsically safe circuit can be assumed to have a temperature classification of T4, provided that P_O does not exceed 1.3 W. Junction boxes and switches in intrinsically safe circuits, however, can be assumed to have a temperature classification of T6 because, by their nature, they do not contain heat dissipating components.

NOTE P_O maximum electrical power in an intrinsically safe circuit that can be taken from the equipment

Table 720-1 Relationship between the temperature classes, surface temperatures and ignition temperature

Temperature class of electrical equipment	Maximum surface temperature of electrical equipment in °C	Ignition temperature of gas or vapour in °C
T1	450	>450
T2	300	>300
T3	200	>200
T4	135	>135
T5	100	>100
T6	85	>85

720:51-0.4 **Selection according to equipment grouping**

720:51-0.4.1 Electrical equipment of types of protection "e", "m", "p" and "q" shall be of equipment group II.

720:51-0.4.2 Electrical equipment of types of protection "d" and "i" shall be of equipment group IIA, IIB or IIC and selected in accordance with Table 720-2.

720:51-0.4.3 Electrical equipment of type of protection "n" shall normally be of equipment group II but, if it contains enclosed break devices, non-incentive components or energy limited equipment or circuits, then the equipment shall be group IIA, IIB or IIC and selected in accordance with Table 720-2.

720:51-0.4.4 Electrical equipment of type of protection "o" shall be of equipment group IIA, IIB or IIC for certain equipment and selected in accordance with Table 720-2.

Table 720-2 Relationship between gas/vapour subdivision and equipment subgroup

Gas/vapour subdivision	Equipment subgroup
IIA	IIA, IIB or IIC
IIB	IIB or IIC
IIC	IIC

720:51-2 **Operational conditions and external influences**

720:51-2.2 **External influences**

720:51-2.2.1 Electrical equipment shall be selected and installed so that it is protected against external influences (e.g. chemical, mechanical, vibrational, thermal, electrical and humidity) which could adversely affect the explosion protection.

720:51-2.2.2 Precautions shall be taken to prevent foreign bodies falling vertically into the ventilation openings of vertical rotating electrical machines.

720:52 Wiring systems

Cable and conduit systems shall comply fully with the relevant requirements of this section except that intrinsically safe installations need not comply with 720:52-0.3, 720:52-0.12, 720:52-7.2.1, 720:52-7.2.2 and 720:52-7.2.3.

720:52-0 General

720:52-0.1 Aluminium conductors

Where aluminium is used as the conductor material, it shall be used only with suitable connections and, with the exception of intrinsically safe installations, shall have a cross-sectional area of at least 16 mm^2.

720:52-0.2 Avoidance of damage

Cable systems and accessories should be installed, so far as is practicable, in positions that will prevent them being exposed to mechanical damage and to corrosion or chemical influences (for example solvents), and to the effects of heat (but see also 723:52-2.14.1.3 for intrinsically safe circuits). Where exposure of this nature is unavoidable, protective measures, such as installation in conduit, shall be taken or appropriate cables selected.

Where cable or conduit systems are subject to vibration, they shall be designed to withstand that vibration without damage.

720:52-0.3 Non-sheathed single cores

Non-sheathed single core cables shall not be used for live conductors, unless they are installed inside switchboards, enclosures or conduit systems.

720:52-0.4 Connections

The connection of cables and conduits to the electrical equipment shall be made in accordance with the requirements of the relevant type of protection.

NOTE 1 The cable should be adequately clamped when the cable entry device does not provide adequate clamping. Such cable entry devices can be marked with the suffix “X”.

NOTE 2 symbol “U” l used to denote an Ex component. Symbol “X” used to denote special conditions for safe use

720:52-0.5 Unused openings

Unused openings for cable or conduit entries in electrical equipment shall be closed with blanking elements suitable for the relevant type of protection. With the exception of intrinsically safe equipment, the means provided for this shall be such that the blanking element can be removed only with the aid of tools.

720:52-0.6 Passage and collection of flammables

Where trunking, ducts, pipes or trenches are used to accommodate cables, precautions shall be taken to prevent the passage of flammable gases, vapours or liquids from one area to another and to prevent the collection of flammable gases, vapours or liquids in trenches.

Such precautions may involve the sealing of trunking, ducts or pipes. For trenches, adequate venting or sand-filling may be used. Conduits and, in special cases, cables (e.g. where there is a pressure differential) shall be sealed, if necessary, so as to prevent the passage of liquids or gases.

720:52-0.7 Circuits traversing a hazardous area

Where circuits traverse a hazardous area in passing from one non-hazardous area to another, the wiring system in the hazardous area shall be appropriate to the Zone(s).

720:52-0.8 Fortuitous contact

Except for trace-heating, fortuitous contact between the metallic armouring/sheathing of cables and pipe work or equipment containing flammable gases, vapours or liquids shall be avoided. The insulation provided by a non-metallic outer sheath on a cable will usually be sufficient to avoid this.

720:52-0.9 Openings in walls

Openings in walls for cables and conduits between hazardous and non-hazardous locations shall be adequately sealed, for example by means of sand seals or mortar sealing to maintain the area classification where relevant.

720:52-0.10 Jointing

Cable runs in hazardous locations should, where practicable, be uninterrupted. Where discontinuities cannot be avoided, the joint, in addition to being mechanically, electrically and environmentally suitable for the situation, it shall be:

- made in an enclosure with a type of protection appropriate to the zone, or
- providing the joint is not subject to mechanical stress, be 'epoxy' filled, compound-filled or sleeved with heat-shrunk tubing or cold-shrunk tubing, in accordance with the manufacturer's instructions.

Conductor connections, with the exception of those in flameproof conduit systems or intrinsically safe circuits, shall be made only by means of compression connectors, secured screw connectors, welding or brazing. Soldering is permissible if the conductors being _______________

720:52-0.11 Protection of stranded ends

If multi-stranded and, in particular, fine-stranded conductors are employed, the ends shall be protected against separation of the strands, for example by means of cable lugs or core end sleeves, or by the type of terminal, but not by soldering alone.

The creepage distances and clearances, in accordance with the type of protection of the equipment, shall not be reduced by the method in which the conductors are connected to the terminals.

720:52-0.12 Unused cores

The hazardous area end of each unused core in multi-core cables shall either be connected to earth or be adequately insulated by means of suitable terminations. Insulation by tape alone is not recommended.

720:52-0.13 Overhead lines

Where an overhead line with uninsulated conductors provides power or telecommunications services to equipment in a hazardous area, it should be terminated in a non-hazardous area and the service continued into the hazardous area with cable or conduit.

720:52-0.14 Cable surface temperature

The surface temperature of cables shall not exceed the temperature class for the installation.

720:52-7 Selection and erection of wiring system to minimize the spread of fire

720:52-7.1 Cable systems for Zone 0

Requirements for cables in an "ia" type of protection installation are defined in Chapter 721.

720:52-7.2 Cable systems for Zones 1 and 2

720:52-7.2.1 Cable for fixed equipment

Mineral-insulated metal sheathed cables, thermoplastic sheathed cables, thermosetting sheathed cables or elastomeric sheathed cables may be used for fixed wiring.

720:52-7.2.2 Cable for portable and transportable apparatus

Portable and transportable electrical apparatus shall have cables with a heavy polychloroprene or other equivalent synthetic elastomeric sheath, cables with a heavy tough rubber sheath, or cables having an equally robust construction. The conductors shall have a minimum cross-sectional area of 1.0 mm^2. If an electrical protective conductor is necessary, it should be separately insulated in a manner similar to the other conductors and should be incorporated within the supply cable sheath.

Portable electrical apparatus with rated voltage not exceeding 250 V to earth and with rated current not exceeding 6 A may have cables:

- with an ordinary polychloroprene or other equivalent synthetic elastomeric sheath,
- with an ordinary tough rubber sheath, or
- with an equally robust construction.

These cables are not admissible for portable electrical apparatus exposed to heavy mechanical stresses, for example hand-lamps, foot-switches, barrel pumps, etc.

If, for portable and transportable electrical apparatus, a metallic flexible armour or screen is incorporated in the cable, this shall not be used as the only protective conductor. The cable should be suitable for the circuit protective arrangements, e.g. where earth monitoring is used, the necessary number of conductors should be included. Where the apparatus needs to be earthed, the cable may include an earthed flexible metallic screen in addition to the PE conductor.

720:52-7.2.3 Flexible cables

Flexible cables in hazardous locations shall be selected from the following:

- ordinary tough rubber sheathed flexible cables;
- ordinary polychloroprene sheathed flexible cables;
- heavy tough rubber sheathed flexible cables;
- heavy polychloroprene sheath;
- plastic insulated cables of equally robust construction to heavy tough rubber sheathed flexible cables.

720:52-7.2.4 Flame propagation

Cables for external fixed wiring shall have flame propagation characteristics which enable them to withstand the tests according to SASO IEC 60332-1, unless they are laid in earth, in sand-filled trenches/ducts or are otherwise protected against flame propagation.

720:52-7.3 Conduit systems

720:52-7.3.1 Conduits shall be provided with stopping boxes where it enters or leaves a hazardous area and adjacent to enclosures to maintain the appropriate degree of protection (e.g. IP54) of the enclosure.

720:52-7.3.2 The conduits shall be pulled up tight at all of the threaded connections.

720:52-7.3.3 Where the conduit system is used as the protective conductor, the threaded junction shall be suitable to carry the fault current which would flow when the circuit is appropriately protected by fuses or circuit-breakers.

720:52-7.3.4 In the event that the conduit is installed in a corrosive area, the conduit material shall either be corrosion resistant or the conduit shall be adequately protected against corrosion. Combinations of metals that can lead to galvanic corrosion shall be avoided.

720:52-7.3.5 After cables are installed in the conduit, stopping boxes shall be filled in accordance with manufacturer′s instructions with a compound which does not shrink on setting and is impervious to, and unaffected by, chemicals found in the hazardous area.

720:52-7.3.6 Non-sheathed insulated single or multicore cables may be used in the conduits. However, when the conduit contains three or more cables, the total cross-sectional area of the cables, including insulation, shall be not more than 40 % of the cross-sectional area of the conduit.

720:52-7.3.7 Long runs of wiring enclosures shall be provided with suitable draining devices to ensure satisfactory draining of condensate. In addition, cable insulation shall have suitable water resistance.

720:52-7.3.8 To meet the degree of protection required by the enclosure, in addition to the use of stopping boxes, it may be necessary to seal between the conduit and the enclosure (for example by means of a sealing washer or non-setting grease).

NOTE Where the conduit is the sole means of earth continuity, this sealing should not reduce the effectiveness of the earth path.

720:53 Isolation switching and control

720:53-3 Devices for protection against overcurrent

720:53-3.1 The requirements of this subsection are not applicable to intrinsically safe circuits.

720:53-3.2 Wiring shall be protected against overload and from the harmful effects of short-circuits and earth faults.

720:53-3.3 All electrical equipment shall be protected against the harmful effects of short-circuits and earth faults.

720:53-3.4 Rotating electrical machinery shall additionally be protected against overload unless it can withstand continuously the starting current at rated voltage and frequency or,in the case of generators,the short-circuit current, without inadmissible heating. The overload protective device shall be

- **a)** a current-dependent, time lag protective device monitoring all three phases, set at not more than the rated current of the machine, which will operate in 2 h or less at 1.20 times the set current and will not operate within 2 h at 1.05 times the set current, or
- **b)** a device for direct temperature control by embedded temperature sensors, or
- **c)** another equivalent device.

720:53-3.5 Transformers shall additionally be protected against overload unless they can withstand continuously the short-circuited secondary current at rated primary voltage and frequency without inadmissible heating or where no overload is to be expected as a result of the connected loads.

720:53-3.6 Short-circuit and earth-fault protection devices shall be such that auto-reclosing under fault conditions is prevented.

720:53-3.7 Precautions shall be taken to prevent operation of multi-phase electrical equipment (e.g. three-phase motors) where the loss of one or more phases can cause overheating to occur.

720:53-3.8 In circumstances where automatic disconnection of the electrical equipment may introduce a safety risk which is more dangerous than that arising from the risk of ignition alone, a warning device (or devices) may be used as an alternative to automatic disconnection provided that operation of the warning device (or devices) is immediately apparent so that prompt remedial action will be taken.

720:53-6 Isolation and switching

720:53-6.2 Isolation

Suitable means of isolation (for example isolators, fuses and links) shall be provided for each circuit or group of circuits (including all circuit conductors with neutral) to allow work to be carried out safely.

Labelling shall be provided immediately adjacent to each means of isolation to permit rapid identification of the circuit or group of circuits thereby controlled.

NOTE There should be effective measures or procedures to prevent the restoration of supply to the equipment whilst the risk of exposing unprotected live conductors to an explosive gas atmosphere continues.

720:53-6.4 Emergency switching

For emergency purposes, at a suitable point or points outside the hazardous area, there shall be single or multiple means of switching off electrical supplies to the hazardous area.

Electrical equipment which must continue to operate to prevent additional danger shall not be included in the emergency switch-off circuit; it shall be on a separate circuit.

720:55 Other equipment

720:55-2 Portable equipment and test equipment

720:55-2.1 Portable equipment should be used in hazardous areas only when its use cannot reasonably be avoided.

720:55-2.2 Portable equipment shall have a type of protection appropriate to the Zone(s) of use. During use, such equipment should not be transferred from a zone of lower risk to a zone of higher risk unless it is suitably protected for the higher risk. In practice, however, such a limitation may be difficult to enforce; it is recommended, therefore, that all portable equipment meet the requirements of the highest risk. Similarly, the equipment group and temperature classification should be appropriate for all the gases and vapours in which the equipment may be used.

720:55-2.3 Ordinary industrial portable equipment shall not be used in a hazardous area unless the specific location has been assessed to ensure that potentially flammable gas or vapour is absent during the period of use (“gas-free” situation). If plugs and sockets are present in a hazardous area, they should be suitable for use in the particular zone and have mechanical and/or electrical interlocking to prevent an ignition source occurring during insertion or removal of the plug. Alternately, they should only be energized in a “gas-free” situation.

720:55-2.4 If electrical testing, for example continuity testing, is necessary to facilitate the installation of hazardous area electrical equipment, care should be taken to ensure that the testing operation is safe for the hazardous area. This may be achieved in various ways including the appropriate use of test equipment which is certified for hazardous area use. Alternatively, testing shall be carried out in a "gas-free" situation.

NOTE Whenever portable electrical equipment is used in a hazardous area, extreme care should be taken to avoid unnecessary risks. Unless specifically permitted by the certification documents for portable electrical equipment or unless other suitable precautions are taken, spare batteries should not be taken into the hazardous area.

CHAPTER 721
ELECTRICAL INSTALLATIONS IN HAZARDOUS LOCATIONS – TYPE OF PROTECTION “D”: FLAMEPROOF ENCLOSURES

721-1 Introduction

Empty flameproof enclosures, which are component certified, shall only be used if the certificate for the assembled equipment makes specific reference to the items contained within the component certified enclosure.

Alteration to the disposition of the internal components of an already certified piece of equipment is not advisable without re-assessment because conditions may be created inadvertently which lead to pressure-piling.

721:11 Scope

This chapter applies to electrical installations in hazardous locations where the electrical equipment has a type of protection "d" using flameproof enclosures.

The requirements of this chapter shall be considered supplementary to the general requirements of electrical installations in hazardous locations covered in Chapter 720.

721:42 Protection against thermal effect

721:42-1 Protection against fire

721:42-1.1 Solid obstacles

When installing equipment, care shall be exercised to prevent the flameproof flange joint approaching nearer than the distance specified in Table 721-1 to any solid obstacle which is not part of the equipment, such as steelwork, walls, weather guards, mounting brackets, pipes or other electrical equipment, unless the equipment has been tested at a smaller distance of separation.

Table 721-1 Minimum distance of obstruction from the flameproof flange joints related to the gas/vapour subgroup of the hazardous area

Gas/vapour subgroup	Minimum distance mm
IIA	10
IIB	30
IIC	40

721:42-1.2 Protection of flameproof joints

Flameproof joints shall be protected against corrosion. The gaps shall be protected against ingress of water. The use of gaskets is only permissible when specified in the equipment documentation. Joints shall not be treated with substances which harden in use.

NOTE 1 A suitable protection method for joints consists of the application of non-setting grease or anti-corrosive agents. Silicone based greases are often suitable for this purpose but care needs to be taken concerning use with gas detectors.

NOTE 2 Flanged faces should not be painted before assembly. Painting of the enclosure after complete assembly is permitted.

721:42-1.3 Motors supplied at varying frequency and voltage

Motors supplied at varying frequency and voltage requires either:

a) means (or equipment) for direct temperature control by embedded temperature sensors specified in the motor documentation or other effective measures for limiting the surface temperature of the motor housing. The action of the protective device shall be to cause the motor to be disconnected. The motor and converter combination does not need to be tested together; or

b) the motor shall have been type-tested for this duty as a unit in association with the converter specified in the descriptive documents according to SASO IEC 60079-0 and with the protective device provided.

721:52 Wiring systems

721:52-0.1 Cable entry systems

721:52-0.1.1 General

721:52-0.1.1.1 It is essential that cable entry systems comply with all the requirements referred to in the appropriate equipment standard, that the cable entry device is appropriate to the type of cable employed, maintains the respective method of protection and is in accordance with 720:52 of Chapter 720.

721:52-0.1.1.2 Where cables enter into flameproof equipment via flameproof bushings through the wall of the enclosure which are part of the equipment (indirect entry), the parts of the bushings outside the flameproof enclosure will be protected in accordance with one of the types of protection listed in SASO IEC 60079-0. Normally, the exposed part of the bushings will be within a terminal compartment which will either be another flameproof enclosure or will be protected by protection type "e". Where the terminal compartment is Ex "d", then the cable system shall comply with 721:52-0.1.2. Where the terminal compartment is Ex "e", then the cable system shall comply with 722:52-0 of Chapter 722.

721:52-0.1.1.3 Where cables enter into flameproof equipment directly, the cable system shall comply with 721:52-0.1.2.

721:52-0.1.1.4 Flameproof cable entry devices may be fitted with a sealing washer between the entry device and the flameproof enclosure providing that after the washer has been fitted, the applicable thread engagement is still achieved. For parallel threads, the thread engagement is normally five full threads or 8 mm, whichever is the greater.

NOTE Ex component part of electrical equipment or a module (other than an Ex cable gland), marked with the symbol "U", which is not intended to be used alone and requires additional consideration when incorporated into electrical apparatus or systems for use in explosive gas atmospheres.

721:52-0.1.2 Selection

The cable entry system shall comply with one of the following:

a) cable entry device in compliance with SASO IEC 60079-1 and certified as part of the equipment when tested with a sample of the particular type of cable;

b) thermoplastic, thermosetting or elastomeric cable which is substantially compact and circular, has extruded bedding and the fillers, if any, are non-hygroscopic; may utilize flameproof cable entry devices, incorporating a sealing ring selected in accordance with Figure 721-1;

c) mineral-insulated cable with or without plastic outer covering with appropriate flameproof cable entry device;

d) flameproof sealing device (for example a stopping box or sealing chamber) specified in the equipment documentation or having component approval and employing cable entry devices appropriate to the cables used. The sealing devices such as stopping boxes or sealing chambers shall incorporate compound or other appropriate seals which permit stopping around individual cores. Sealing devices shall be fitted at the point of entry of cables to the equipment;

e) flameproof cable entry devices incorporating compound filled seals around the individual cores or other equivalent sealing arrangements;

f) other means which maintain the integrity of the flameproof enclosure.



a Internal sources of ignition include sparks or equipment temperatures occurring in normal operation which can cause ignition. An enclosure containing terminals only or an indirect entry enclosure (see 721:52-0.1.1) is considered not to constitute an internal source of ignition.

b The term 'volume' is defined in SASO IEC 60079-1.

Figure 721-1 Selection chart for cable entry devices into flameproof enclosures for cables complying with item b) of 721:52-0.1.2

721:52-0.2 Conduit systems

721:52-0.2.1 Conduits shall be selected from the following:

a) screwed heavy gauge steel, solid drawn or seam welded; or

b) flexible conduit of metal or composite material construction (e.g. metal conduit with a plastic or elastomer jacket), of heavy or very heavy mechanical strength classification in accordance with ISO 10807.

721:52-0.2.2 A minimum of five threads shall be provided on the conduit to permit the engagement of five threads between the conduit and flameproof

enclosure, or conduit and coupling. The tolerance class of the conduit thread shall be 6 g.

721:52-0.2.3 Stopping boxes shall be provided in the enclosure, on the wall or not more than 50 mm from the wall of flameproof enclosures to limit the pressure piling effect and to prevent hot gases from entering the conduit system from an enclosure containing a source of ignition.

721:52-0.2.4 Where the enclosure is specifically designed for connection to wiring in conduits but is required to be connected by cables, then a flameproof adapter, complete with bushings and terminal box, may be connected to the conduit entry of the enclosure with a length of conduit which is as short as reasonably practicable and not longer than 50 mm. The cable can then be connected to the terminal box (for example flameproof or increased safety) according to the requirements of the type of protection of the terminal box.

721:52-0.2.5 Blanking elements (flameproof stoppers) should be connected directly to the conduit entry of the enclosure.

CHAPTER 722
ELECTRICAL INSTALLATIONS IN HAZARDOUS LOCATIONS – TYPE OF PROTECTION “E”: INCREASED SAFETY

722:11 Scope

This Chapter applies to electrical installations in hazardous locations where the electrical equipment has a type of protection "e" or increased safety.

The requirements of this chapter shall be considered supplementary to the general requirements of electrical installations in hazardous locations covered in Chapter 720.

722:41 Protection against electric shock

722:41-2 Protection against direct contact

722:41-2.2 Degree of protection of enclosures

Enclosures containing bare live parts will have a degree of protection of at least IP54, whereas enclosures containing insulated parts only will have a degree of protection of at least IP44. Rotating electrical machinery (except for terminal boxes and bare conducting parts) installed in clean environments and regularly supervised by trained personnel needs to be protected by an enclosure with a degree of protection of only IP20. The restriction of application will be marked on the machine.

722:52 Wiring systems

722:52-0.1 General

Cables and conduits shall be installed in accordance with 720:52 of Chapter 720 and the following additional requirements concerning cable entries and conductor terminations.

722:52-0.2 Cable entry devices

722:52-0.2.1 The connection of cables to increased safety equipment shall be effected by means of cable entry devices appropriate to the type of cable used. They shall maintain protection type “e”, incorporate a suitable sealing component to achieve the required degree of protection of the terminal enclosure (minimum IP54) and meet the mechanical impact strength requirements of SASO IEC 60079-0.

NOTE 1 To meet the ingress protection requirement it may also be necessary to seal between the cable entry device and the enclosure (for example by means of a sealing washer or thread sealant).

NOTE 2 In order to meet the minimum requirement of IP54, threaded cable entry devices into threaded cable entry plates or enclosures of 6 mm or greater thickness need no additional sealing between the cable entry device and the entry plate or enclosure providing the axis of the cable entry device is perpendicular to the external surface of the cable entry plate or enclosure.

722:52-0.2.2 Where mineral-insulated metal sheathed cables are used, the requirement to achieve creepage distances shall be maintained by using a suitable sealing device.

722:52-0.3 Conductor terminations

722:52-0.3.1 Where more than one conductor is connected to the same terminal, care shall be taken to ensure that each conductor is adequately clamped.

Unless permitted by the documentation supplied with the equipment, two conductors of different cross-sectional area shall not be connected into one terminal unless they are first secured with a single compression type ferrule.

722:52-0.3.2 To avoid the risk of short-circuits between adjacent conductors in terminal blocks, the insulation of each conductor shall be maintained up to the metal of the terminal.

722:52-0.4 Combinations of terminals and conductors for general connection and junction boxes

Care shall be taken to ensure that the heat dissipated within the enclosure does not result in temperatures in excess of the required equipment temperature class. This can be achieved by:

a) following the guidance given by the manufacturer relating to the permissible number of terminals, the conductor size and the maximum current, or

b) checking that the calculated dissipated power, using parameters specified by the manufacturer, is less than the rated maximum dissipated power.

722:53 Isolation switching and control

722:53-2 Devices for Protection against thermal effects

722:53-3 Devices for Protection against overcurrent

722:53-3.2 Cage induction motors – Thermal protection in operation

722:53-3.2.1 Overload protection

722:53-3.2.1.1 In order to meet the requirements of 720:53-3, item a), inverse-time delay overload protective devices shall be such that not only is the motor current monitored, but the stalled motor will also be disconnected within the time t_E stated on the marking plate. The current-time characteristic curves giving the delay time of the overload relay or release as a function of the ratio of the starting current to the rated current shall be held by the user.

722:53-3.2.1.2 Delta wound machines, phase imbalance protection shall be provided which will detect machine imbalances before they can give rise to excessive heating effects.

722:53-3.2.1.3 In general, motors designed for continuous operation, involving easy and infrequent starts which do not produce appreciable additional heating, are acceptable with inverse-time delay overload protection. Motors designed for arduous starting conditions or which are to be started frequently are acceptable only when suitable protective devices ensure that the limiting temperature is not exceeded.

722:53-3.2.2 Winding temperature sensors

In order to meet the requirements of 720:53-3, item b), winding temperature sensors associated with protective devices shall be adequate for the thermal protection of the machine even when the machine is stalled. The use of embedded temperature sensors to control the limiting temperature of the machine is only permitted if such use is specified in

the machine documentation. The type of built-in temperature sensors and associated protective device will be identified on the machine.

722:53-3.2.3 Soft starts

The overload protection of motors which are started by means of special procedures limiting electrical, mechanical or thermal stresses by electrical means shall be subject to specific assessment by the user for the condition, if the requirements of 722:53-3.2.1 cannot be met.

722:53-3.2.4 Varying frequency and voltage

Motors supplied at varying frequency and voltage by a converter shall have been type tested for this duty as a unit in association with the converter specified in the descriptive documents according to SASO IEC 60079-0 and with the protective device provided or shall be evaluated in accordance with SASO IEC 60079-7.

NOTE Additional information on the application of converter-fed motors can be found in SASO IEC 60034-17. Major concerns include over-temperature, high frequency and overvoltage effects, and bearing currents.

722:55 Other equipment

722:55-2 Resistance-heating devices

722:55-2.1 The heating devices and protective devices, where required, shall be installed in accordance with the requirements of the manufacturer and the documentation.

722:55-2.2 The temperature protective device, if required, shall de-energize the resistance-heating device either directly or indirectly. It shall be of a type that has to be manually reset.

722:55-2.3 In addition to the overcurrent protection, and in order to limit the heating effect due to abnormal earth-fault and earth-leakage currents, the following protection shall be installed:

a) in a TT or TN type system, a residual current device (RCD) with a rated residual operating current not exceeding 300 mA shall be used. Preference should be given to RCDs with a rated residual operating current of 30 mA. The device shall have a maximum break time not exceeding 5 s at the rated residual operating current and not exceeding 0.15 s at five times the rated residual operating current;

b) in an IT system, an insulation monitoring device shall be used to disconnect the supply whenever the insulation resistance is not greater than 50 Ω per volt of rated voltage.

CHAPTER 723
ELECTRICAL INSTALLATIONS IN HAZARDOUS LOCATIONS – TYPE OF PROTECTION "I": INTRINSIC SAFETY

723-1 Introduction

A fundamentally different installation philosophy has to be recognized in the installation of intrinsically safe circuits. In comparison with all other types of installations, where care is taken to confine electrical energy to the installed system as designed so that a hazardous environment cannot be ignited, the integrity of an intrinsically safe circuit has to be protected from the intrusion of energy from other electrical sources so that the safe energy limitation in the circuit is not exceeded, even when breaking, shorting or earthing of the circuit occurs.

As a consequence of this principle, the aim of the installation rules for intrinsically safe circuits is to maintain separation from other circuits.

723:11 Scope

This chapter applies to electrical installations in hazardous locations where the electrical equipment has a type of protection "i" or intrinsic safety.

The requirements of this chapter shall be considered supplementary to the general requirements of electrical installations in hazardous locations covered in Chapter 720.

723:41 Protection against electric shock

723:41-3 Protection against indirect contact
723:41-3.1 Automatic disconnection of supply
723:41-3.1.2 Equipotential bonding for Zones 1 and 2
723:41-3.1.2.1 Earthing of conducting screens

- Where a screen is required, except as in a) through c) below, the screen shall be electrically connected to earth at one point only, normally at the non-hazardous area end of the circuit loop. This requirement is to avoid the possibility of the screen carrying a possibly incentive level of circulating current in the event that there are local differences in earth potential between one end of the circuit and the other.
- If an earthed intrinsically safe circuit is run in a screened cable, the screen for that circuit should be earthed at the same point as the intrinsically safe circuit which it is screening.
- If an intrinsically safe circuit or sub-circuit which is isolated from earth is run in a screened cable, the screen should be connected to the equipotential bonding system at one point.
- Special cases:
  a) If there are special reasons (for example when the screen has high resistance, or where screening against inductive interference is additionally required) for the screen to have multiple electrical connections throughout its length.
  b) If the installation is effected and maintained in such a manner that there is a high level of assurance that potential equalization exists between each end of the circuit (i.e. between the

hazardous area and the non-hazardous area), then, if desired, cable screens may be connected to earth at both ends of the cable and, if required, at any interposing points.

c) Multiple earthing through small capacitors (for example 1 nF, 1500 V ceramic) is acceptable provided that the total capacitance does not exceed 10 nF.

723:41-3.1.2.2 Cable armour bonding

- Armour should normally be bonded to the equipotential bonding system via the cable entry devices or equivalent, at each end of the cable run. Where there are interposing junction boxes or other equipment, the armour will normally be similarly bonded to the equipotential bonding system at these points. In the event that armour is required not to be bonded to the equipotential bonding system at any interposing point, care should be taken to ensure that the electrical continuity of the armour from end to end of the complete cable run is maintained.
- Where bonding of the armour at a cable entry point is not practical, or where design requirements make this not permissible, care should be taken to avoid any potential difference which may arise between the armour and the equipotential bonding system giving rise to an incentive spark. In any event, there shall be at least one electrical bonding connection of the armour to the equipotential bonding system. The cable entry device for isolating the armour from earth shall be installed in the non-hazardous area or Zone 2.

723:51 Common rules

723:51-4 Identification

723:51-4.2 Marking of cables for Zones 1 and 2

- Cables containing intrinsically safe circuits shall be marked (except as below) to identify them as being a part of an intrinsically safe circuit. If sheaths or coverings are marked by a colour, the colour used shall be blue. Where intrinsically safe circuits have been identified by the use of blue covered cable, then blue covered cable shall not be used for other purposes in a manner or location which could lead to confusion or detract from the effectiveness of the identification of intrinsically safe circuits.
- If all intrinsically safe or non-intrinsically safe cables are armoured, metal sheathed or screened, then marking of intrinsically safe cables is not required.
- Alternative marking measures shall be taken inside measuring and control cabinets, switchgear, distribution equipment, etc. where there is a risk of confusion between cables of intrinsically safe and non-intrinsically safe circuits, in the presence of a blue neutral conductor. Such measures include:
  a) combining the cores in a common blue harness;
  b) labelling;
  c) clear arrangement and spatial separation.

723:52 Wiring systems

723:52-2 Selection and erection of wiring systems in relation to external influences

723:52-2.14 Nature of processed or stored materials

723:52-2.14.1 Cables Installations

723:52-2.14.1.1 General

- Only insulated cables whose conductor-earth, conductor-screen and screen-earth test voltages are at least 500 V a.c. or 750 V d.c. shall be used in intrinsically safe circuits.
- The diameter of individual conductors within the area subject to explosion hazards shall be not less than 0.1 mm. This applies also to the individual wires of a finely stranded conductor.

723:52-2.14.1.2 Electrical parameters of cables

The electrical parameters (C_c and L_c) or (C_c and L_c/R_c) for all cables used (see 723:61) shall be determined according to a), b) or c):

a) the most onerous electrical parameters provided by the cable manufacturer;

b) electrical parameters determined by measurement of a sample;

c) 200 pF/m and either 1 μH/m or 30 μH/Ω where the interconnection comprises two or three cores of a conventionally constructed cable (with or without screen).

C_c : Equivalent internal capacitance of the cable

L_c : Equivalent internal inductance of the cable

L_c/R_c : Ratio of inductance (L_c) to resistance (R_c) the cable

723:52-2.14.1.3 Installation of cables in relation to external influences

- Installations with intrinsically safe circuits shall be erected in such a way that their intrinsic safety is not adversely affected by external electric or magnetic fields such as from nearby overhead power lines or heavy current-carrying single core cables. This can be achieved, for example, by the use of screens and/or twisted cores or by maintaining an adequate distance from the source of the electric or magnetic field.
- In addition to the cable requirements of 720:52-0, cables in both hazardous and non-hazardous locations shall meet one of the following requirements:
  a) intrinsically safe circuit cables are separated from all non-intrinsically safe circuit cables; or
  b) intrinsically safe circuit cables are so placed as to protect against the risk of mechanical damage; or
  c) intrinsically safe or non-intrinsically safe circuit cables are armoured, metal sheathed or screened.
- Conductors of intrinsically safe circuits and non-intrinsically safe circuits shall not be carried in the same cable (see 720:55-0.3).
- Conductors of intrinsically safe circuits and non-intrinsically safe circuits shall not be in the same bundle or duct unless separated by an intermediate layer of insulating material or by an earthed metal partition. No separation is required if metal sheaths or screens are used for the intrinsically safe or non-intrinsically safe circuits.
- Each unused core in a multi-core cable should either:

a) be adequately insulated from earth and from each other at both ends by the use of suitable terminations, or
b) if other circuits in the multicore have an earth connection (e.g. via the associated equipment), be connected to the earth point used to earth any intrinsically safe circuits in the same cable, but should be adequately insulated from earth and from each other by the use of suitable terminations at the other end.

723:52-2.14.1.4 Multi-core cables containing more than one intrinsically safe circuit

- The requirements of this substatement are in addition to those of 723:52-2.14.1.1 to 723:52-2.14.1.3.
- Multi-core cables may contain more than one intrinsically safe circuit but intrinsically safe and non-intrinsically safe circuits should not be carried in the same multi-core (see 723:55-0.3).
- The radial thickness of the conductor insulation shall be appropriate to the conductor diameter and the nature of the insulation. The minimum radial thickness shall be 0.2 mm.
- The conductor insulation shall be such that it will be capable of withstanding an . a.c. test voltage of twice the nominal voltage of the intrinsically safe circuit with a minimum of 500 V.
- Multi-core cables shall be of a type capable of withstanding a dielectric test of at least.
- 500 V . a.c. or 750 V d.c. applied between any armouring and/or screen(s) joined together and all the cores joined together.
- 1000 V . a.c. or 1500 V d.c. applied between a bundle comprising one half of the cable cores joined together and a bundle comprising the other half of the cores joined together. This test is not applicable to multi-core cables with conducting screens for individual circuits.
- The voltage tests shall be carried out by a method specified in an appropriate cable standard. Where no such method is available, the tests shall be carried out in accordance with SASO IEC 60079-11.

723:52-2.14.1.5 Fault considerations in multi-core cables

The faults, if any, which shall be taken into consideration in multi-core cables used in intrinsically safe electrical systems depend upon the type of cable used.

a) Type A

For cables complying with the requirements of 723:52-2.14.1.4 and, in addition, with conducting screens providing individual protection for intrinsically safe circuits in order to prevent such circuits becoming connected to one another, coverage of such screens shall be at least 60 % of the surface area. No faults between circuits are taken into consideration.

b) Type B

Cable which is fixed, effectively protected against damage, complying with the requirements of 723:52-2.14.1.4 and, in addition, no circuit contained within the cable has a maximum voltage U_O exceeding 60 V. No faults between circuits are taken into consideration.

c) Others

For cables complying with the requirements of 723:52-2.14.1.4 but not the additional requirements of Type A or Type B, it is necessary to take into consideration up to two short-circuits between

conductors and, simultaneously, up to four open circuits of conductors. In the case of identical circuits, failures shall not be taken into consideration provided that each circuit passing through the cable has a safety factor of four times that required for category “ia” or “ib”.

NOTE The type of installation detailed in the preceding paragraph is sometimes referred to as Type C.

For cables not complying with the requirements of 723:52-2.14.1.4, there is no limit to the number of short-circuits between conductors and, simultaneously, between open circuits of conductors which shall be taken into consideration.

723:52-2.14.2 Cable entry devices

Cable entry devices into junction boxes of type of protection “e” or “n”, which contain only intrinsically safe circuits, do not need to be certified and do not need to maintain the “e” or “n” characteristics of the enclosure. The same goes for appropriate ingress protection, provided that it measures at least IP20 (see 720:51-2.2).

723:52-2.14.3 Termination of intrinsically safe circuits

723:52-2.14.3.1 In electrical installations with intrinsically safe circuits, for example in measuring and control cabinets, the terminals shall be reliably separated from the non-intrinsically safe circuits (e.g. by a separating panel or a gap of at least 50 mm). The terminals of the intrinsically safe circuits shall be marked as such.

723:52-2.14.3.2 Terminals for intrinsically safe circuits shall be separated from terminals for non-intrinsically safe circuits by one of the methods, a) or b), given below:

a) When separation is accomplished by distance, then the clearance between terminals shall be at least 50 mm. Care shall be exercised in the layout of terminals and in the wiring method used so that contact between circuits is unlikely if a wire becomes dislodged.

b) When separation is accomplished by use of an insulating partition or earthed metal partition, the partitions used shall extend to within 1.5 mm of the walls of the enclosure, or alternatively provide a minimum measurement of 50 mm between the terminals when taken in any direction around the partition.

723:52-2.14.3.3 The minimum clearances between the bare conducting parts of external conductors connected to terminals and earthed metal or other conducting parts shall be 3 mm.

723:52-2.14.3.4 The clearance between the bare conducting parts of terminals of separate intrinsically safe circuits shall be such that there is at least 6 mm between the bare conducting parts of connected external conductors.

723:52-2.14.3.5 Plugs and sockets used for connection of external intrinsically safe circuits shall be separate from, and non-interchangeable with, those for non-intrinsically safe circuits. Where the equipment is fitted with more than one plug and socket for external connections and interchange could adversely affect the type of protection, such plugs and sockets shall either be arranged so that interchange is not possible, e.g. by keying, or mating plugs and sockets shall be identified, e.g. by marking or colour coding, to make interchange obvious (see 723:55-0.3).

723:52-2.14.3.6 Where terminals are arranged to provide separation of circuits by spacing alone, care shall be taken in the layout of terminals and the wiring method used to prevent contact between the circuits should a wire become disconnected.

723:54 Earthing arrangements, protective conductors and protective bonding conductors

723:54-2 Earthing arrangements

723:54-2.1 Earthing of intrinsically safe circuits for Zones 1 and 2

723:54-2.1.1 Intrinsically safe circuits may be either:

a) isolated from earth, or

b) connected at one point to the equipotential bonding system if this exists over the whole area in which the intrinsically safe circuits are installed.

723:54-2.1.2 The installation method shall be chosen with regard to the functional requirements of the circuits and in accordance with the manufacturer's instructions.

723:54-2.1.3 More than one earth connection is permitted on a circuit, provided that the circuit is galvanically separated into subcircuits, each of which has only one earth point.

723:54-2.1.4 In intrinsically safe circuits which are isolated from earth, attention shall be paid to the danger of electrostatic charging. A connection to earth across a resistance of between 0.2 MΩ and 1 MΩ, for example for the dissipation of electrostatic charges, is not deemed to be earthing.

723:54-2.1.5 Intrinsically safe circuits shall be earthed if this is necessary for safety reasons, for example in installations with safety barriers without galvanic isolation. They may be earthed if necessary for functional reasons, for example with welded thermocouples. If intrinsically safe equipment does not withstand the electrical strength test with at least 500 V a.c. to earth according to SASO IEC 60079-11, a connection to earth for the equipment is to be assumed.

723:54-2.1.6 Where the equipment is earthed (e.g. by the method of mounting) and a bonding conductor is used between the equipment and the point of earth connection of the associated equipment, conformity with a) or b) is not required. Such situations should receive careful consideration by a competent person and in any case should not be used for circuits without galvanic isolation entering Zone 0. If bonding conductors are employed, they should be adequate for the situation, have a copper cross-sectional area of no less than 4 mm^2, be permanently installed without the use of plugs and sockets, adequately mechanically protected, and have terminations which, with the exception of the IP rating, conform to the requirements of type of protection “e”.

723:54-2.1.7 In intrinsically safe circuits, the earthing terminals of safety barriers without galvanic isolation (for example Zener barriers) shall be:

a) connected to the equipotential bonding system by the shortest practicable route, or

b) for TN-S systems only, connected to a high-integrity earth point in such a way as to ensure that the impedance from the point of connection to the main power system earth point is less than 1 Ω. This may be achieved by connection to a switch-room earth bar or by

the use of separate earth rods. The conductor used shall be insulated to prevent invasion of the earth by fault currents which might flow in metallic parts with which the conductor could come into contact (for example control panel frames). Mechanical protection shall also be provided in places where the risk of damage is high.

723:54-2.1.8 The cross-section of the earth connection shall consist of:

a) at least two separate conductors each rated to carry the maximum possible current, which can continuously flow, each with a minimum of 1.5 mm^2 copper, or

b) at least one conductor with a minimum of 4 mm^2 copper.

NOTE The provision of two earthing conductors should be considered to facilitate testing.

723:54-2.1.9 If the prospective short-circuit current of the supply system connected to the barrier input terminals is such that the earth connection is not capable of carrying such current, then the cross-sectional area shall be increased accordingly or additional conductors used.

723:54-2.1.10 If the earth connection is achieved via junction boxes, special care should be taken to ensure the continued integrity of the connection.

723:54-2.2 Earthing of intrinsically safe circuits for Zone 0

In installations with intrinsically safe circuits for Zone 0, the intrinsically safe equipment and the associated equipment shall comply with SASO IEC 60079-11, category "ia". Associated equipment with galvanic isolation between the intrinsically safe and non-intrinsically safe circuits is preferred. Since only one fault in the equipotential bonding system, in some cases, could cause an ignition hazard, associated equipment without galvanic isolation may be used only if the earthing arrangements are in accordance with item b) of 723:54-2.1.7 and any mains-powered equipment connected to the safe area terminals are isolated from the mains by a double wound transformer, the primary winding of which is protected by an appropriately rated fuse of adequate breaking capacity. The circuit (including all simple components, simple electrical equipment, intrinsically safe equipment, associated equipment and the maximum allowable electrical parameters of inter-connecting cables) shall be of category "ia".

723:55 Other equipment

723:55-0.1 Equipment Installations for Zones 1 and 2

723:55-0.1.1 In installations with intrinsically safe circuits for Zones 1 or 2, the intrinsically safe equipment and the intrinsically safe parts of associated equipment shall comply with SASO IEC 60079-11, at least to category "ib".

723:55-0.1.2 Simple equipment need not be marked, but shall comply with the requirements of SASO IEC 60079-0 and SASO IEC 60079-11, in so far as intrinsic safety is dependent on them.

723:55-0.1.3 Associated equipment should preferably be located outside the hazardous area or, if installed inside a hazardous area, shall be provided with another appropriate type of protection in accordance with 720:32-1 which is suitable for the ignition sources which the associated equipment may present.

723:55-0.1.4 Electrical equipment connected to the non-intrinsically safe terminals of an associated equipment shall not be fed with a voltage supply greater than U_m shown on the label of the associated equipment. The prospective short-circuit current of the supply shall not be greater than 1500 A.

NOTE (U_m) maximum a.c. or d.c. voltage : maximum voltage that can be applied to the non-intrinsically safe connection facilities of associated apparatus without invalidating intrinsic safety

723:55-0.1.5 The components and wiring of intrinsically safe equipment and associated equipment (e.g. barriers) should normally be mounted in enclosures offering a degree of protection of at least IP20 to protect against unauthorized interference and damage. Alternative methods of mounting may be used if they offer similar integrity against interference and damage (e.g. mounted in racks in a normally locked switch-room).

723:55-0.1.6 All equipment forming part of an intrinsically safe system should, where reasonably practicable, be identifiable as being part of an intrinsically safe system. This recommendation may be met by conformity with 723:51-4.2.

723:55-0.2 Equipment Installations for Zone 0

Intrinsically safe circuits shall be installed in accordance with 723:55-0.1 except where modified by the following special requirements:

a) Simple equipment installed outside Zone 0 shall be referred to in the system documentation and shall comply with the requirements of SASO IEC 60079-11, category "ia".

b) If earthing of the circuit is required for functional reasons, the earth connection shall be made outside Zone 0, but as close as is reasonably practicable to the Zone 0 equipment.

c) If part of an intrinsically safe circuit is installed in zone 0 such that the equipment and the associated equipment are at risk of developing hazardous potential differences within Zone 0, e.g. through the presence of atmospheric electricity, a surge protection device shall be installed between each non-earth bonded core of the cable and the local structure as near as is reasonably practicable, preferably within 1 m, to the entrance to Zone 0. Examples of such locations are flammable liquid storage tanks, effluent treatment plants and distillation columns in petrochemical works. A high risk of potential difference is generally associated with a distributed plant and/or exposed equipment location, and the risk is not alleviated simply by using underground cables or tank installation.

d) The surge protection device shall be capable of diverting a minimum peak discharge current of 10 kA (8/20 µs impulse according to SASO IEC 60060-1, 10 operations). The connection between the protection device and the local structure shall have a minimum cross-sectional area equivalent to 4 mm² copper.

e) The spark-overvoltage of the surge protection device shall be determined by the user and an expert for the specific installation.

NOTE The use of a surge protection device with spark-overvoltage below 500 V a.c. 60 Hz may require the intrinsically safe circuit to be regarded as being earthed.

f) The cable between the intrinsically safe equipment in Zone 0 and the surge protection device shall be installed such that it is protected from lightning.

723:55-0.3 Special applications

723:55-0.3.1 For some special applications, such as the monitoring of power cables, circuits using the principles of intrinsic safety are included in the same cable as power circuits. Such installations require a specific analysis of the risks involved.

723:55-0.3.2 For special applications, intrinsically safe and non-intrinsically safe circuits are permitted in the same plug and socket assembly, provided that it is of an acceptable design and that intrinsic safety is not required when the other circuits are energized.

723:61 Verification of intrinsically safe circuits

Unless a system certificate is available defining the parameters for the complete intrinsically safe circuit, then the whole of this section shall be complied with.

When installing intrinsically safe circuits, including cables, the maximum permissible inductance, capacitance or L/R ratio and surface temperature shall not be exceeded. The permissible values shall be taken from the associated equipment documentation or the marking plate.

723:61-1 Intrinsically safe circuits with only one associated equipment

The sum of the maximum effective internal capacitance C_i or inductance L_i of each item of intrinsically safe equipment and the cable capacitance or inductance shall not exceed the maximum value C_o or L_o marked on the associated equipment.

Where the intrinsically safe equipment contains no effective inductance and the associated equipment is marked with an inductance/resistance L/R value, if the L/R value of the cable, measured between the two cores in the cable having maximum separation, is less than this figure, it is not necessary to satisfy the L_o requirement.

The values of permissible input voltage U_i, input current I_i and input power P_i of each intrinsically safe equipment shall be greater than or equal to the values U_o, I_o and P_o respectively of the associated equipment.

For simple equipment the maximum temperature can be determined from the values of P_o of the associated equipment to obtain the temperature class. The temperature class can be determined by:

a) reference to Table 723-1, or

b) calculation using the formula:

$$T = P_o R_{th} + T_{amb}$$

where

- T is the surface temperature;
- P_o is the power marked on the associated equipment;
- R_{th} is the thermal resistance (K/W) (as specified by the component manufacturer for the applicable mounting conditions);
- T_{amb} is the ambient temperature (normally 40°C) and reference to Table 720-1.

In addition, components with a surface area smaller than 10 cm^2 (excluding lead wires) may be classified as T5 if their surface temperature does not exceed 150°C.

The equipment group of the intrinsically safe circuit is the same as the most restrictive grouping of any of the items of electrical equipment forming that circuit (for example a circuit with IIB and IIC equipment will have a circuit grouping of IIB).

Table 723-1 Assessment for T4 classification according to component size and ambient temperature

Total surface area excluding lead wires	Requirement for T4 classification (based on 40°C ambient temperature)
<20 mm^2	Surface temperature ≤275°C
≥20 mm^2 ≤10 cm^2	Surface temperature ≤200°C
≥20 mm^2	Power not exceeding 1.3 W *
* Reduced to 1.2 W with 60°C ambient temperatures or 1.0 W with 80°C ambient temperatures.	

723:61-2 Intrinsically safe circuits with more than one associated equipment

If two or more intrinsically safe circuits are interconnected, the intrinsic safety of the whole system shall be checked by means of theoretical calculations or a spark ignition test in accordance with SASO IEC 60079-11. The equipment group, temperature class and the category shall be determined.

Account shall be taken of the risk of feeding back voltages and currents into associated equipment from the rest of the circuit. The rating of voltage and current-limiting elements within each associated equipment shall not be exceeded by the appropriate combination of U_O and I_O of the other associated equipment.

A descriptive system document shall be prepared by the system designer in which the items of electrical equipment and the electrical parameters of the system, including those of inter-connecting wiring, are specified.

CHAPTER 724
ELECTRICAL INSTALLATIONS IN HAZARDOUS LOCATIONS – TYPE OF PROTECTION "P": PRESSURIZED EQUIPMENT

724-1 Introduction

Unless it has been assessed as a whole, the complete installation shall be checked by an expert for compliance with the requirements of the equipment documentation and the requirements of this chapter and related referenced standards.

The coding shown on a certificate relating to equipment certified as conforming to one of the pressurization equipment standards will always include "Ex p". It may also contain the letter "p" in conjunction with other letters, e.g. a certified flameproof enclosure containing a certified pressurization control system might be marked (according to SASO IEC 60079-2 as "Ex d [p]".

NOTE 1 The [p] indicates either:

a) that the flameproof enclosure contains a component certified pressurization control system whose certificate number will end in the letter "U", or
b) that the flameproof enclosure contains a pressurization control system certified for use with a specific pressurized enclosure. In this case separate assessment or certification needs to be carried out if the system is to be used on a different pressurized enclosure design.

NOTE 2 The fitting of a certified pressurization control system onto an uncertified pressurized enclosure does not confer certification on the pressurized enclosure or its contents.

NOTE 3 An empty pressurized enclosure may or may not have a separate component certificate. Electrical equipment installed inside even a component certified pressurized enclosure is not fully certified unless a separate certificate of conformity refers to the actual contents fitted.

724:11 Scope

This chapter applies to electrical installations in hazardous locations where the electrical equipment has a type of protection "p" or pressurized equipment.

The requirements of this chapter shall be considered supplementary to the general requirements of electrical installations in hazardous locations covered in Chapter 720:

724:52 Wiring systems

724:52-7 Selection and erection of wiring systems to minimize the spread of fire

724:52-7.1 Ducting

724:52-7.1.1 All ducts and their connecting parts shall be able to withstand a pressure equal to:

- 1.5 times the maximum overpressure, specified by the manufacturer of the pressurized equipment, for normal operation, or
- the maximum overpressure that the pressurizing source can achieve with all the outlets closed where the pressurizing source (for example a fan) is specified by the manufacturer of the pressurized equipment, with a minimum of 200 Pa (2 mbar).

724:52-7.1.2 The materials used for the ducts and connecting parts shall not be adversely affected by the specified protective gas or by the flammable gas or vapours in which they are to be used.

724:52-7.1.3 The points at which the protective gas enters the supply duct(s) shall be situated in a non-hazardous area, except for cylinder supplied protective gas.

724:52-7.1.4 Ducting should be located in a non-hazardous area as far as is reasonably practicable. If ducting passes through a hazardous area and the protective gas is at a pressure below atmospheric then the ducting shall be free from leaks.

724:52-7.1.5 Ducts for exhausting the protective gas should preferably have their outlets in a non-hazardous area. Consideration shall otherwise be given to the fitting of spark and particle barriers (i.e. devices to guard against the ejection of ignition-capable sparks or particles) as shown in Table 724-1.

Table 724-1 Use of spark and particle barriers

Zone of exhaust duct outlet	Equipment	
	A	B
Zone 2	Required	Not required
Zone 1	Required*	Required*

A Equipment which may produce ignition-capable sparks or particles in normal operation.

B Equipment which does not produce ignition-capable sparks or particles in normal operation.

* If the temperature of the enclosed equipment constitutes a hazard upon failure of pressurization, a suitable device shall be fitted to prevent the rapid entry of the surrounding atmosphere into the pressurized enclosure.

724:52-7.1.6 Pressurizing equipment, such as an inlet fan or compressor that is used to supply protective gas should preferably be installed in a non-hazardous area. Where the drive motor and/or its control equipment are located within the supply ducting, or where the installation in a hazardous area cannot be avoided, the pressurizing equipment shall be suitably protected.

724:52-7.2 **Action to be taken on failure of pressurization**

- Pressurization control systems are sometimes fitted with override devices or "maintenance switches" which are intended to allow the pressurized enclosure to remain energized in the absence of pressurization, e.g. when the enclosure door has been opened.
- Such devices should be used in a hazardous area only if the specific location has been assessed to ensure that potentially flammable gas or vapour is absent during the period of use ("gas-free" situation). The enclosure should be de-energized at once if flammable gases are detected while operating under these conditions and re-purged before it is put back into service.

NOTE It is only necessary to re-purge the enclosure after pressurization has been re-established if flammable gas was detected in the area while the manual override was in operation.

724:52-7.2.1 Equipment without an internal source of release

- An installation comprising electrical equipment without an internal source of release shall comply with Table 724-2 when the pressurization with the protective gas fails.

  NOTE Pressurized enclosures protected by static pressurization should be moved to a non-hazardous area for refilling if pressurization is lost.
- The pressure monitoring devices lock out if pressure is lost and should only be reset after pressure has been restored following refilling.

Table 724-2 Action to be taken when the pressurization with the protective gas fails for electrical equipment without an internal source of release

Area classification	Enclosure contains equipment not suitable for zone 2 without pressurization	Enclosure contains equipment suitable for zone 2 without pressurization
Zone 2	Alarm [a]	No action
Zone 1	Alarm and switch-off [b]	Alarm [a]

NOTE Restoration of pressurization should be completed as soon as possible, but in any case within 24 h. During the time that the pressurization is inoperative, action should be taken to avoid the entry of flammable material into the enclosure. Provided that pressurized equipment is switched off automatically upon pressurization failure, an additional alarm may not be necessary for safety, even in a zone 1 hazardous area. If power is not switched off automatically, e.g. in a zone 2 hazardous area, an alarm is the minimum action that is recommended if combined with immediate action by the operator to restore the pressurization or switch off the equipment.

Equipment within the enclosure suitable for the external zone need not be switched off when pressure fails.

[a] If the alarm operates, immediate action should be taken, for example to restore the integrity of the system.

[b] If automatic switch-off would introduce a more dangerous condition, other precautionary measures should be taken, for example duplication of protective gas supply.

724:52-7.2.2 Equipment with an internal source of release

- Equipment with an internal source of release shall be installed in accordance with the manufacturer's instructions.
- In particular, any containment system safety devices that are required for safety but which were not actually supplied with the equipment, e.g. sample flow limiters, pressure regulators or in-line flame arrestors, should be fitted by the user.
- Where the pressurized enclosure has an internal containment system that allows process fluids or gases to be taken into the enclosure, the likelihood and effect of the pressurizing gas leaking into the process system should be considered. For example, if a low-pressure process gas in a containment system is at a lower pressure than the pressurizing air, any leakage path into the containment system will allow air into the process and produce a potentially adverse or dangerous effect on the process.
- In the event of failure of the protective gas, an alarm shall be given and corrective action taken to maintain the safety of the system.
- The action to be taken on pressure or flow failure should be decided by the user, taking into account at least the following considerations:
  a) the manufacturer's recommendations;

b) the nature of the release from the containment system (e.g. “none”, “limited” or “unlimited”);
c) the constituents of the internal release, e.g. liquid or gas, and their flammability limits;
d) whether or not the flammable substance supply is automatically shut off upon pressure/flow failure;
e) the nature of the equipment inside the enclosure, e.g. incentive, suitable for zone 1 or suitable for Zone 2, and its proximity to the source of release;
f) the external area classification, e.g. Zone 1 or Zone 2;
g) the type of protective gas used, e.g. air or inert gas. In the latter case, the enclosure should always be re-purged after pressure has been lost to restore the high concentration of inert gas (and low concentration of oxygen) required to provide adequate protection;
h) the consequences of unannounced automatic shutdown of the equipment.

- Where the sample gas has a high upper explosive limit (UEL) e.g. >80 %, or where the gas is capable of reacting exothermically even in the absence of air, e.g. ethylene oxide, it is not possible to protect the enclosure with inert gas using “leakage compensation” techniques. The use of the “continuous flow” technique with air or inert gas is suitable if the flow rate is high enough to dilute the release to a concentration below 25 % of the lower explosive limit (LEL), or to a level below which decomposition cannot take place.

724:52-7.3 Multiple pressurized enclosures with a common safety device
Requirements for the use of a common safety device with more than one pressurized enclosure are given in SASO IEC 60079-2.

724:52-7.4 Purging

724:52-7.4.1 The minimum purge time, specified by the manufacturer, for the pressurized enclosure shall be increased by the minimum additional purging duration per unit volume of ducting, specified by the manufacturer, multiplied by the volume of the ducting.

724:52-7.4.2 In Zone 2, providing that it is established that the atmosphere within the enclosure and associated ducting is well below the lower flammable limit (for example 25 % LEL) purging may be omitted. Additionally, gas detectors may be used to check whether the gas in the pressurized enclosure is flammable.

724:52-7.4.3 The protective gas used for purging, pressurization and continuous dilution shall be non-combustible and non-toxic. It shall also be substantially free from moisture, oil, dust, fibres, chemicals, combustibles and other contaminating material that may be dangerous or affect the satisfactory operation and integrity of the equipment. It will usually be air, although an inert gas may be used. The protective gas shall not contain more oxygen by volume than that normally present in air.

724:52-7.4.4 Where air is used as the protective gas, the source shall be located in a non-hazardous area and usually in such a position as to reduce the risk of contamination. Consideration shall be given to the effect of nearby

structures on air movement and of changes in the prevailing wind direction and velocity.

724:52-7.4.5 The temperature of the protective gas should not normally exceed 40°C at the inlet of the enclosure. (In special circumstances, a higher temperature may be permitted or a lower temperature may be required, in which case the temperature will be marked on the pressurized enclosure.)

724:52-7.4.6 Where necessary, to prevent the ingress of combustible gas or vapour by diffusion, or to prevent leakage of protective gas, wiring systems shall be sealed.

NOTE This does not preclude a cable duct or a conduit being purged with the equipment.

724:52-7.4.7 Cable entry devices into pressurized enclosures shall be in accordance with the equipment documentation.

WARNING: Where inert gas is used, particularly in large enclosures, great care should be taken to prevent asphyxiation.

724:52-7.5 Pressurized rooms and analyzer houses

724:52-7.5.1 Pressurized rooms

Requirements for electrical installations in pressurized rooms shall be in accordance with SASO IEC 60079-13.

724:52-7.5.2 Analyzer houses

Requirements for electrical installations in analyser houses shall be in accordance with SASO IEC 60079-16 and SASO IEC 61285.

CHAPTER 725
ELECTRICAL INSTALLATIONS IN HAZARDOUS LOCATIONS – EQUIPMENT SUITABLE ONLY FOR USE IN ZONE 2

725-1 Introduction

The following additional requirements only apply to equipment in accordance with items b) and c) of 720:51-0.2.3.

NOTE Type of protection "n" is divided into five sub-types:

- nA is for non-sparking equipment;
- nC is for sparking equipment in which the contacts are suitably protected other than by a restricted-breathing enclosure, energy limitation and simplified pressurization;
- nR is for restricted breathing enclosures;
- nL is for energy limited equipment;
- nZ is for enclosures with "n" pressurization.

725:11 Scope

This chapter applies to electrical installations in hazardous locations where the electrical equipment is suitable only for use in Zone 2.

The requirements of this Chapter shall be considered supplementary to the general requirements of electrical installations in hazardous locations covered in Chapter 720.

725:41 Protection against electric shock

725:41-1 Protection against both direct and indirect contact

725:41-1.2 Energy-limited equipment and circuits

The sum of the maximum internal capacitance of each equipment and the cable capacitances (cables being considered as concentrated capacitance equal to the maximum capacitance between two adjacent cores), and the sum of the maximum inductance of each equipment and the cable inductance (cable being considered as concentrated inductance equal to the maximum inductance between the two cores in the cable having the maximum separation) shall not exceed the maximum permissible capacitance and inductance values, respectively. These values will be marked on protection type "n" equipment or given in the documentation.

725:41-2 Protection against direct contact

725:41-2.2 Degree of protection of enclosures

725:41-2.2.1 Enclosures containing bare live parts and enclosures containing only insulated parts require a degree of protection of at least IP54 and IP44, respectively.

725:41-2.2.2 When used in locations providing adequate protection against the entry of solid foreign bodies or liquids capable of impairing safety (for example indoors), enclosures containing bare live parts and enclosures containing only insulated parts require a degree of protection of IP4X and IP2X, respectively.

725:41-2.2.3 Equipment which would not be impaired by contact with solid foreign bodies or liquids (for example strain gauges, resistance thermometers, thermocouples, energy-limited equipment, etc.) need not comply with the above requirements.

725:52 Wiring systems

725:52-0.1 General

Cables and conduits shall be installed in accordance with 720:52, with the following additional requirements concerning cable entries and conductor terminations.

725:52-0.2 Cable entry devices

725:52-0.2.1 The connection of cables shall be carried out by means of cable entry devices appropriate to the type of cable used.

725:52-0.2.2 To meet the degree of protection requirement of the terminal enclosure, it may be necessary to use cable entry devices incorporating suitable sealing components to seal between the cable entry device and the cable. Sealing may be similarly required between the cable entry device and the enclosure (for example by means of a sealing washer or thread sealant).

NOTE Threaded cable entry devices into threaded cable entry plates or enclosures of 6 mm or greater thickness need no additional sealing between the cable entry device and the entry plate or enclosure, providing the axis of the cable entry device is perpendicular to the external surface of the cable entry plate or enclosure.

725:52-0.2.3 The sealing of restricted-breathing enclosures shall be such as to maintain the restricted-breathing properties of the enclosure.

NOTE The above requirements can be met by, for example, the use of a suitable sealing washer between the cable entry device and the enclosure (irrespective of the form of the cable entry), cable with an extruded inner bedding and a cable entry device with an inner seal. Conduit or tapered threads will require the use of a thread sealant (see 720:52-7.3).

725:52-0.2.4 Unused cable entries shall be closed with plugs which maintain the degree of protection of the terminal enclosure.

725:52-0.3 Conductor terminations

725:52-0.3.1 Some terminals, such as slot types, may permit the entry of more than one conductor. Where more than one conductor is connected to the same terminal, care shall be taken to ensure that each conductor is adequately clamped. Unless permitted by the documentation supplied with the equipment, two conductors of different cross-sections shall not be connected into one terminal unless they are first secured with a single compression type ferrule.

725:52-0.3.2 Where there is a risk of short-circuits between adjacent conductors in terminal blocks, the insulation of each conductor shall be maintained up to the metal of the terminal.

NOTE Where single screw saddle clamps are used with a single conductor, the latter should be shaped around the screw in the form of a “U” unless clamping of single conductors without “U” is permitted in the documentation supplied with the equipment.

725:55 Other equipment

725:55-2 Personal electrical equipment

Items of personal equipment which are battery or solar operated (e.g. electronic wrist watches, hearing aids, car alarm remote controls, key ring torches, calculators, etc.) are sometimes carried by personnel and inadvertently taken into a hazardous area.

The risk with electronic watches is small and their use in a hazardous area is generally acceptable.

All other personal battery or solar operated equipment (including electronic wrist watches incorporating a calculator) should be either assessed for use in the hazardous area or should only be taken into the hazardous area after a certificate guaranteeing the absence of a flammable atmosphere has been issued.

NOTE An increased risk is associated with lithium batteries which may be used to power personal electronic equipment and their use should be assessed as described in this subsection.

CHAPTER 726
PLACES OF ASSEMBLY

726:11 Scope

This chapter applies to all buildings or portions of buildings designed or intended for the assembly of 50 or more persons. Places of assembly shall include but not be limited to the following: Mosques, Colleges and Schools, Celebration (festival) halls, Auditoriums, Conference rooms, Courtrooms, Restaurants and Dining facilities, Clubrooms and Gymnasiums, Museums and Places of awaiting transportation.

This chapter does not apply to the outdoor places of assembly.

Temporary electrical installations located in places of assembly shall comply with Chapter 711.

726:31 Purposes, supplies and structure

726:31-3 Supplies

The nominal supply voltage of electrical installations shall not exceed 220/380 V a.c. (see SASO 182).

726:41 Protection against electric shock

726:41-2 Protection against direct contact

726:41-2.3 Protection by obstacles

Protection by obstacles is not applicable.

726:41-2.4 Protection by placing out of reach

Protection by placing out of reach is not applicable.

726:41-2.5 Additional protection by residual current devices

All socket-outlets rated up to 32 A shall be additionally protected by residual current devices with a rated residual operating current not exceeding 30 mA. One residual current protective device shall protect not more than six socket-outlets.

This requirement does not apply to socket-outlets supplied by a circuit incorporating protection by SELV and/or protection by electrical separation.

726:41-3 Protection against indirect contact

726:41-3.1 Protection by automatic disconnection of supply

726:41-3.1.3 TN system

Where the type of system earthing is TN, the installation shall be TN-S.

726:41-3.3 Protection by non-conducting locations

Protection by non-conducting locations is not applicable.

726:41-3.4 Protection by earth free local equipotential bonding

Protection by earth free local equipotential bonding is not applicable.

726:42 Protection against thermal effects

726:42-2 Measures for protection against fire

726:42-2.2 Conditions of evacuation in an emergency

726:42-2.2.1 Wiring systems shall not encroach on escape routes unless the wiring is provided with sheaths or enclosures which, for two hours,

- will not contribute to, or propagate a fire, and

- will not attain a temperature high enough to ignite adjacent material.

Wiring systems encroaching on escape routes shall not be within arm's reach unless they are provided with protection against mechanical damage likely to occur during an evacuation. Any wiring systems in escape routes shall be as short as practicable.

726:42-2.2.2 If switchgear and controlgear devices are placed in passages, they shall be enclosed in cabinets or boxes constructed of non-combustible or not readily combustible material.

726:42-2.2.3 In escape routes, the use of electrical equipment containing flammable liquids is prohibited.

726:51 Common rules

Switchgear and controlgear devices, except certain devices used to facilitate evacuation or those parts designed and intended to be operated by ordinary persons (BA1) as defined in 51-2.2, shall be placed in closed cabinets, which can only be opened by the use of a key or a tool.

Switchboards are only accessible to skilled persons (BA5). They are located:

- in a room which is kept locked, or
- in cabinets having a degree of protection of at least IP2X or IPXXB.

NOTE 1 It is recommended to locate these cabinets in areas where they do not risk to obstructing movement or being damaged.

726:52 Wiring systems

726:52-1 Types of wiring systems

726:52-1.1 Cable system shall be either:

- flame retardant in accordance with SASO 752 or SASO 1274, and low smoke in accordance with SASO 2701, or
- single or multicore unarmoured cables enclosed in metallic or non-metallic conduit or trunking, providing fire protection in accordance with SASO 254 and SASO 255 or SASO IEC 61084.

726:52-7 Selection and erection of wiring systems to minimize the spread of fire

The requirements of 52-7 shall be applied.

726:55 Other equipment

726:55.6 Safety services

726:55-6.7 Safety (Emergency) lighting circuits

Emegency lighting circuits shall comply with the requirements of 55-6.7.

726:55-7 Socket-outlets

726:55-7.1 An adequate number of socket-outlets shall be installed to allow the users' requirements to be met safely.

NOTE The adequate number depends on the nature of the place, however one socket-outlet per 10 m^2 may be suitable in most places.

726:55-7.2 If necessary, Floor mounted socket-outlets may be used in mosques, sports halls and gymnasiums.

726:55-7.3 Where a floor mounted socket-outlet is installed, it shall have a degree of protection not less than IPX4.

726:55-7.4 Socket-outlets shall not be mounted at locations where they are liable to come into physical contact with fabrics or other flammable materials that may catch fire due to transmission of heat.

726:55-9 **Luminaires**

726:55-9.1 All emergency exists shall be provided by an emergency exit lighting. Emergency escape route lighting shall be provided to direct occupants to an exit.

726:55-9.2 Installation of escape route lighting shall comply with SASO 2012.

726:55-9.3 Open area (anti-panic) emergency lighting shall comply with SASO 2012.

726:55-9.4 For the selection of luminaires with regard to their thermal effect on the surroundings, 55-9.5 shall be applied.

726:802 **Ligtning protection systems**

A risk assessment study shall be carried out. For the calculation of accepted frequency Nc of lightning flashes to a building, the coeffecient C4 shall be equal to 3.0 (difficult to evacuate or risk of panic).

726:803 **Fire detection and alarm systems**

Every building shall be provided with a proper fire detection and alarm system in accordance with Chapter 803 and SBC 800.

CHAPTER 730
ELECTRIC SIGNS AND OUTLINE LIGHTING

730:11 Scope

This chapter specifies the requirements and methods of installation for signs and luminous discharge-tube installations operating from a no-load rated output voltage exceeding 1000 V but not exceeding 10000 V, including the electrical components and wiring.

The standard covers installations used for publicity, decorative or general lighting purposes, either for external or internal use. Such signs or luminous-discharge-tube installation may be either fixed or portable supplied from a low-voltage (LV) or extra-low-voltage (ELV) source by means of a transformer, inverter or converter.

730:31-3 Installation of the mains supply

Installation of the mains supply for signs and luminous-discharge-tube installations shall be carried out in accordance with these Electrical Requirements.

730:41 Protection against electric shock

730:41-2 Protection against direct contact

730:41-2.1 Insulation of live parts

All high-voltage connections to discharge tubes shall be protected by means of insulating sleeves.

730:41-2.2 Barriers or enclosures

730:41-2.2.1 Additional protection shall consist of an enclosure or other means of protection conforming to the following:

a) It shall provide a degree of protection corresponding to at least IP 2X as specified in SASO 980.

NOTE 1 The requirements for protection against ingress of solid objects, specified in EN 60529, do not apply.

b) If it is constructed from metal parts, these shall be earthed in accordance with 730:54-4.

c) If it is constructed from other materials, these shall be materials that have been certified by the supplier as suitable for use in the environment existing close to a tube electrode. The installer shall obtain from the supplier a guarantee for the materials covering the expected lifetime of the installation.

NOTE 2 Suppliers of such materials should be informed of the temperature, ultraviolet (UV) radiation, ozone and other conditions existing near a tube electrode. They should also be informed that such materials might be used in exterior situations.

d) Access to the interior of an enclosure shall be by means of a tool, e.g. a screwdriver.

NOTE 3 Other means of additional protection may be permanent, e.g. it may have to be cut away using a knife.

NOTE 4 A fully enclosed sign letter or box sign is considered to be a suitable enclosure for this purpose.

730:41-2.2.2 Additional protection shall consist of either:

a) An enclosure as specified in 730:41-2.2.1 where the degree of protection (IP 2X) is maintained even if any external parts of a tube are broken, or

b) An enclosure as specified in 730:41-2.2.1 plus open-circuit protection conforming to the requirements of EN 50107-2.

NOTE The requirement of 730:41-2.2.2 means that it is not possible to insert the appropriate test finger into the broken end of a tube and touch a live electrode.

730:41-2.2.3 Additional protection shall consist of open-circuit protection conforming to the requirements of EN 50107-2.

730:41-2.2.4 A conductor which is in metallic contact with a discharge tube operating at high voltage shall not be in connection (except in respect of its connection to earth) with any other conductor of the mains supply or with the primary winding of the transformer.

730:41-2.4 Placing out of reach

730:41-2.4.1 High-voltage connections situated within arm's reach shall have additional protection conforming to 730:41-2.2.1 and 730:41-2.2.2.

730:41-2.4.2 High-voltage connections situated out of arm's reach shall have additional protection conforming to 730:41-2.2.1 or 730:41-2.2.3.

730:51 Common rules

730:51-4 Identification

730:51-4.1 Marking

The following details shall be marked permanently and legibly on a suitable plate or label attached to, or positioned in a clearly visible place close to, the sign or luminous discharge-tube installation:

a) the name and address of the sign manufacturer or company responsible for the installation;

b) the year of the installation.

730:51-4.2 Symbols for ‘caution, risk of electric shock’ shall be fixed at points of access to any sign, luminous-discharge-tube installation or enclosure containing high-voltage transformers, invertors or converters.

NOTE In small installation of limited extent one such symbol is normally adequate. More than one symbol should be used for larger installation and these should be arranged so that at least one is visible from any likely direction of approach to the installation.

730:51-5 Prevention of mutual detrimental influence

730:51-5.3 Electromagnetic compatibility

Components fitted to enable the sign or luminous-discharge-tube installation to conform to the Electromagnetic Compatibility Directive (IED) shall be rated for the voltages and frequencies to which they will be subjected.

730:52 Wiring systems

730:52-2 Selection and erection of wiring system to external influences

730:52-2.3 Presence of water

730:52-2.3.2 Drain holes

In sign enclosures intended for external use, arrangements shall be made to allow moisture to drain away. Drain holes or similar apertures used for this purpose shall be sufficiently large to ensure that they do not become blocked with dirt or debris between maintenance visits.

730:52-2.6 Means of attachment of signs

Electrical conductors shall be not used as means of suspension or attachment of signs.

730:53 Isolation, switching and control

730:53-1 Devices for protection against indirect contact by automatic disconnection of supply.

730:53-1.2 Earth-leakage and open-circuit protection (Residual current devices)

730:53-1.2.1 The safety and performance requirements for earth-leakage and open-circuit protection devices are specified in EN 50107-2.

730:53-1.2.2 All high-voltage circuits supplied from transformers, inverters or converters, with the exception of Type A converters as specified in relevant Saudi Standards (EN 61347-2-10), shall be protected by an residual current device conforming to 730:53-1.2.3. The installer shall ensure that performance of the residual current device is certified by the manufacturer of the device as conforming to EN 50107-2.

730:53-1.2.3 In the event of accidental contact between the high-voltage circuit and earth, the residual current device shall either disconnect the mains supply to the input circuit, or otherwise remove the earth-leakage (residual) current.

NOTE A standard residual-current-operated circuit-breaker is not a suitable protective device for this application since, when connected to the primary side of a transformer, inverter or converter, it does not protect against faults to earth on the secondary side.

730:53-1.2.4 In the event of an open circuit occurring in the high-voltage circuit, the open-circuit protective device shall either disconnect the mains supply to the input circuit, or otherwise remove the output voltage.

730:53-1.2.5 If the circuit includes a flasher, any protective switch and its reset circuit shall be installed on the mains-supply side of the flasher.

NOTE If they were on the other side of the flasher, the switch would keep re-setting and re-tripping during fault conditions.

730:53-1.2.6 If the circuit includes a flasher and the device(s) to remove the output power is incorporated within the housing of the transformer(s), inverter(s) or converter(s), either a protective switch shall be connected on the mains-supply side of the flasher and the incorporated sensor circuits shall be capable of operating this second switch; or other means shall be provided to prevent the protective device resetting every time the flasher switches the mains supply off and on again.

730:54 Earthing arrangements, protective conductors and protective bonding conductors

730:54-3 The protective conductors

The protective conductor shall be copper and one of the following:

a) a separate cable having insulation colored yellow/green and having the following cross-sectional area:
   - i) in situations where it may suffer mechanical stress 4 mm²,
   - ii) in other situations 2.5 mm².

or

b) a stranded or solid conductor having a minimum cross-sectional area of not less than 1.5 mm², manufactured as part of a sheathed high-tension cable and protected by the overall sheath of that cable; or

c) the braided metal screen of a high-voltage cable, provided that the total cross-sectional area of the individual strands comprising that screen is not less than 1.5 mm².

Connections to the screen shall be made by unraveling the braid and twisting the individual strands together to form a suitable length of conductor to attach to an earth terminal. The connection shall not be by means of a metal clamp around the braid.

730:54-4 **Protective bonding conductors**

730:54-4.1 The protection against indirect contact shall be provided by equipotential bonding, applied between all metal parts and then connected to earth.

730:54-4.2 All exposed metal work, with the exception of clips and clamps for fixing cables and tubes, shall be bonded together by means of a protective conductor and, unless this metal work is connected to earth by other means, shall be provided with an earthing terminal.

730:54-4.3 Where metal parts are joined together, means shall be employed to ensure that earth continuity is maintained across the joint.

NOTE This is particularly import ant where the metal parts are painted or where they are joined together by adhesive.

730:54-4.4 Equipotential bonding conductors shall be not connected to the neutral terminal of the mains supply to the sign or luminous-discharge-tube installation, except as specified in this for protective multiple earthing arrangements in TN-C systems.

730:55 Other equipment

730:55-2 Transformers

Transformers shall conform to EN 61050.

730:55-3 Inverters and converters

Inverters and converters shall conform to EN 61347-2-10.

730:61 Verification- Initial verification

730:61-0.2 Except for small portable signs, which are accompanied by a certificate from their manufacturer, indicating conformity to this chapter, signs or luminous-discharge-tube installations shall be inspected in accordance with 730:61-0.3.

730:61-0.3 **Site records**

To assist in the maintenance of the sign or luminous-discharge-tube installation, the sign installer shall supply the sign owner or operator a simplified circuit diagram, data sheet or other means identifying which transformer(s), inverter(s) or converter(s) are operating which tube(s) (refer to annex F.61).

730:61-1.3 When the installation has been completed, the installer shall check that the sign or luminous-discharge-tube installation conforms to this standard.

NOTE Particular care should be taken to ensure conformity of the following items:

a) the types of high-voltage cable used and their installation;
b) the high-voltage connections;
c) the creepage distances and clearances;
d) the earthing connections;
e) the mechanical details of the sign or luminous-discharge-tube installation necessary to ensure conformity to this standard.

730:61-2 Testing

The following electrical tests shall be carried out on the completed sign. The test in 730:61-2.1 shall be carried out at the installation site following the inspections specified the test in 730:61-2.2 may be carried out on site or in the premises where the sign is manufactured, as convenient.

730:61-2.1 Earth-leakage and open-circuit protective devices shall be tested in accordance with the instructions provided by the supplier of those devices. Such tests shall be used to determine whether the units are functioning properly and have been installed correctly.

NOTE 1 The requirement for the manufacturer of the device to provide this information is specified in EN 50107-2 and to 730:53-1.2.2.

NOTE 2 Such tests are not intended to test the performance of the devices. The installer is required to obtain the relevant certification.

730:61-2.2 Unless operated from a constant-current transformer, inverter or converter, the tube current in each circuit shall be measured to ensure that it lies within the tolerance specified by the manufacturer of the transformer, inverter or converter.

CHAPTER 740
AMUSEMENT DEVICES AND BOOTHS AT FAIRGROUNDS, AMUSEMENT PARKS AND CIRCUSES

740:11 Scope

This chapter specifies the minimum electrical installation requirements to facilitate the safe design, installation and operation of mobile, temporarily or permanently installed electrical machines and structures which incorporate electrical equipment. The machines and structures are intended to be installed repeatedly, without loss of safety, temporarily or permanently, at fairgrounds, amusement parks, circuses or any other places.

For non-electrical safety, SASO relevant standards shall be applied.

The object of this chapter is to define the electrical installation requirements for such structures and machines, both being either integral parts or constituting the total amusement device.

This chapter does not apply to the electrical equipment of machines (see SASO IEC 60204-1).

740:31 Purposes, supplies and structure

740:313 Supplies

740:313.1.3 Voltage

The nominal supply voltage of temporary electrical installations in booths, stands and amusement devices shall not exceed 220/380 V a.c. in accordance with SASO 182.

740:31-3.3 Supply from the public network

Irrespective of the number of sources of supply, the phase and neutral conductors from different sources shall not be interconnected. The instructions of the supply network operator shall be followed.

740:41 Protection against electric shock

740:41-0 Introduction

740:41-0.3 Application of measures of protection against electric shock

740:41-0.3.2 Application of measures of protection against direct contact

Protective measures against direct contact by means of obstacles (see 41-2.3 of Chapter 41) and by placing out of reach (see 41-2.4 of Chapter 41) shall not be used.

740:41-0.3.3 Application of measures of protection against indirect contact

Protective measures against indirect contact by non-conducting location (see 41-3.3 of Chapter 41) and by earth-free equipotential bonding (see 41-3.4 of Chapter 41) shall not be used.

740:41-0.3.4 Application of measures of protection in relation to external influences

740:41-0.3.4.3.1 Automatic disconnection of supply to the temporary structures shall be provided at the origin of the installation by RCDs with a rated residual operating current not exceeding 300 mA. These RCDs shall incorporate a time delay in accordance with SASO IEC 60947-2 or be of the S-type in

accordance with SASO IEC 61008-1 or SASO IEC 61009-1 for discrimination with RCDs protecting final circuits.

NOTE The recommendation for additional protection relates to the increased risk of damage to cables in temporary locations.

740:41-0.3.4.3.2 In order to prevent all supplies from being disconnected and causing danger (including non-electrical danger by the loss of motive power or lighting), it may be necessary to utilise more than one circuit.

740:41-2 Protection against direct contact

740:41-2.5 Additional protection by residual current devices

Except for emergency lighting, all final circuits for lighting, socket-outlets rated up to 32 A and portable equipment connected by means of flexible cable or cord with a current-carrying capacity of 32 A or less shall be additionally protected by RCDs with a rated residual operating current not exceeding 30 mA.

This requirement does not apply to socket-outlets supplied by a circuit incorporating one or more of the protective measures specified below:

- protection by SELV;
- protection by electrical separation;
- protection by automatic disconnection of supply and reduced low-voltage.

740:41-3 Protection against indirect contact

740:41-3.1 Protection by automatic disconnection of supply

NOTE For supplies to large a.c. motors, the use of RCDs with time delay is recommended.

740:41-3.1.3 TN system

If the supply is a TN system, only the TN-S system shall be used.

740:41-3.1.3.3 For the application of the protective measure against indirect contact by automatic disconnection of supply, the conventional touch voltage limit in locations in which animals may be present is U_L = 25 V a.c. or 60 V d.c., and the maximum disconnecting time is that indicated in Table 41-3 of Chapter 41.

These conditions also apply to locations connected by conductive parts to the locations where animals may be present.

740:41-3.1.5 IT system

Where an alternative system is available, an IT system shall not be used. IT systems, however, may be used for d.c. applications in accordance with SASO IEC 62020. Where an IT system is used, permanent earth fault monitoring shall be provided.

740:41-3.1.6 Supplementary equipotential bonding

740:41-3.1.6.1 In locations used for animals, supplementary equipotential bonding shall connect all exposed conductive parts and extraneous conductive parts which can be touched simultaneously to the protective conductor of the installation.

If a metallic grid is laid in the floor, it shall be connected to the local supplementary bonding required for locations where animals are kept.

740:42 Protection against thermal effects

740:42-2 Measures for protection against fire

740:42-2.3 Nature of processed or store materials

740:42-2.3.8 A motor which is automatically or remotely controlled and which is not continuously supervised shall be fitted with a manually reset protective device against excess temperature.

740:51 Common rules

Switchgear and controlgear shall be placed in cabinets, which can be opened only by the use of a key or a tool, except for those parts designed and intended to be operated by ordinary persons (Code BA1), as defined in Table 51-1.

740:52 Wiring systems

740:52-1 Types of wiring systems

740:52-1.6 Cables

Where appropriate, cables shall be of flexible construction.

Armoured cables or cables protected against mechanical damage shall be used wherever there is a risk of mechanical damage.

All temporary power distribution cables shall be multi-core, except for circuits above 125 A where single-core cables may be used.

All cables shall meet the requirements of SASO 752.

NOTE Where enhanced performance is required, cables should meet the requirements of SASO 1274; where low smoke cables are needed, the minimum recommended performance is given in SASO IEC 61034-2.

Cables shall have a minimum voltage designation of 450/750 V, except that, within amusement devices, cables and cords having a minimum voltage designation of 300/500 V may be used.

The routes of cables buried in the earth shall be marked at suitable intervals. Buried cables shall be protected against mechanical damage.

740:52-6 Electrical connections

Joints shall not be made in cables and cords, except where necessary as a connection to a circuit. Any joint shall be made in an enclosure affording a degree of protection not less than IP4X or IPXXD.

Where strain may be transmitted to terminals, cable anchorage shall be provided.

740:53 Isolation, Switching and Control

740:53-6.2 Isolation

740:53-6.2.1 General

740:53-6.2.1.5 Every separate temporary electrical installation for amusement devices and each distribution circuit supplying outdoor installations shall be provided with its own readily accessible and properly identified means of isolation.

740:53-6.2.2 Devices for isolation

740:53-6.2.2.1 Devices for isolation shall disconnect all phases, poles and the neutral.

740:53-6.2.2.9 Every electrical installation of a booth, stand or amusement device shall have its own means of isolation and overcurrent protection, which shall be readily accessible.

740:55 Other equipment

740:55-1 Low-voltage generating sets

740:55-1.8 Generators

All generators shall be so located or protected as to prevent danger and injury to people through inadvertent contact with hot surfaces and dangerous parts. Reference to injury and danger in this sub-subsection also includes non-electrical danger and injury.

Electrical equipment associated with the generator shall be mounted securely and, if necessary, on anti-vibration mountings.

Significant changes in generator frequency and/or voltage shall be prevented.

Where a generator supplies a temporary installation, using a TN, TT or IT system, care shall be taken to ensure that the earthing arrangements are in accordance with 54-2.1 of Chapter 54 and, in cases where earth electrodes are used, with 54-2.2 of Chapter 54.

For TN systems, all exposed conductive parts shall be connected to the generator using a protective conductor with a cross-sectional area in accordance with 54-3.

The neutral conductor of the star-point of the generator shall, except for IT-systems, be connected to the exposed conductive parts of the generator.

740:55-6 Safety isolating transformers and electronic converters

Multiple connection safety isolating transformers shall comply with SASO IEC 61558-2-6 or provide an equivalent degree of safety.

A manually reset protective device shall protect the secondary circuit of each transformer or electronic converter (see SASO IEC 60204-1).

Safety isolating transformers shall be mounted out of arm's reach of the public and shall have adequate ventilation. Access by skilled or instructed persons for testing and protective device maintenance shall be provided.

Electronic converters shall conform to SASO IEC 61347.

Enclosures containing rectifiers and transformers shall be adequately ventilated and the vents not obstructed when in use.

740:55-7 Socket-outlets and plugs

An adequate number of socket-outlets shall be installed to allow the user's requirements to be met safely.

Not more than one flexible cable or cord shall be connected to a plug, unless the plug is specifically designed for multiple connections.

Multi-way plug-in type adapters shall not be used.

740:55-8 Electrical supply

At each amusement device, there shall be a connection point readily accessible and permanently marked to indicate the following essential characteristics:

- rated voltage;
- rated current;
- rated frequency.

740:55-9 Luminaires and lighting installation

740:55-9.4 General Requirements for installation

740:55-9.4.1 Luminaires

All luminaires and decorative chains shall be securely attached to the structure or support intended to carry them. Their weight shall not be carried by the supply cable, unless it has been selected and erected for this purpose.

Luminaires and decorative chains mounted less than 2.5 m (arm's reach) above floor level or otherwise accessible to accidental contact shall be firmly fixed, and so sited or guarded as to prevent risk of injury to persons or ignition of materials. Access to the fixed light source shall only be possible after removing a barrier or an enclosure, which operation shall require the use of a tool.

740:55-9.4.2 Lampholders

Insulation-piercing lampholders shall not be used unless the cables and lampholders are compatible and the lampholders are non-removable once fitted to the cable.

740:55-9.4.3 Lamps in shooting galleries

All lamps in shooting galleries and other side-shows where projectiles are used shall be suitably protected against accidental damage.

740:55-9.4.4 Floodlights

When transportable floodlights are used, they shall be mounted so that the luminaire is inaccessible. Supply cables shall be flexible and have adequate protection against mechanical damage.

740:55-9.4.5 Fire risks for luminaires and floodlights

Luminaires and floodlights shall be so fixed and protected that a focusing or concentration of heat is not likely to cause ignition of any material.

740:55-9.4.6 Electrical discharge lamp installations

Installations of any luminous tube, signs or lamps on a booth, stand or amusement device with an operating voltage higher than 220/380 V a.c. shall comply with the following.

740:55-9.4.6.1 Location

The sign or lamp shall be installed out of arm's reach or shall be adequately protected to reduce the risk of injury to persons.

740:55-9.4.6.2 Installation

The fascia or material behind luminous tube, signs or lamps shall be non-ignitable and protected as required by SASO standards.

Controlgear with output voltages higher than 220/380 V a.c. shall be mounted on non-ignitable material.

740:55-9.4.6.3 Emergency switching device

A separate circuit shall be used to supply such signs or lamps, which shall be controlled by an emergency switch. The switch shall be easily visible, accessible and marked in accordance with the requirements of the local authority.

740:61 Verification

The whole electrical installation shall be inspected and tested after each assembly on site in accordance with Chapter 61.

CHAPTER 750
LIFTS AND ESCALATORS

750:11 **Scope**

The particular requirements of this chapter apply to the electrical installation supplying power to electric lifts, hydraulic lifts, escalators and passenger conveyors and to their internal electrical installations for rated voltages not exceeding 220/380 V.

They do not apply to the electrical equipment of lifts and escalators including machines, control circuits, operating devices and signaling equipment (see SASO 466).

The requirements for escalators are applicable for passenger conveyors (moving walks).

For non-electrical safety, SASO 467 and other relevant Saudi Standards shall be applied.

750:31 **Purposes, supplies and structure**

750:31-3 **Supplies**

750:31-3.1.3 **Voltage**

The nominal supply voltage of electrical installations in lifts and escalators shall be 127/220 V a.c. or 220/380 V a.c.

750:41 **Protection against electric shock**

750:41-1 **Protection against both direct and indirect contact**

750:41-1.1 **SELV and PELV**

750:41-1.1.4 **Requirements for unearthed circuits (SELV)**

750:41-1.1.4.3 Where SELV is used, whatever the nominal voltage, protection against direct contact shall be provided by:

- barriers or enclosures affording at least the degree of protection IP2X or IPXXB, or
- insulation capable of withstanding a test voltage of 500 V a.c. for 1 min.

750:41-2 **Protection against direct contact**

750:41-2.1 **Insulation of live parts**

The insulation resistance of the electrical installations, excluding the electronic devices, shall not be less than:

- 1 Mega-Ohm for power circuits and electric safety device circuits.
- 0.5 Mega-Ohm for lighting, controls, signaling and ventilation circuits.

750:41-2.3 **Obstacles**

Protection by obstacles is not applicable.

750:41-2.4 **Placing out of reach**

Protection by placing out of reach is not applicable.

750:41-3 **Protection against indirect contact**

750:41-3.1 **Automatic disconnection of supply**

750:41-3.1.3 **TN system**

If the supply is a TN system, only the TN-S system shall be used.

750:41-3.1.6 Supplementary equipotential bonding

All extraneous conductive parts in lifts and escalators shall be connected by equipotential bonding conductors and connected to the protective conductor of the exposed conductive parts of equipment.

- The nominal cross-sectional area of bonding conductors shall be not less than 4 mm^2.
- The installation earth resistance shall not exceed 0.5 ohms at any point on the protective conductor.
- In the earthing arrangement, all connections must be permanently soldered, not clamped, connections.

750:41-3.3 Protection by non-conducting locations

Protection by non-conducting locations is not applicable.

750:41-3.4 Protection by earth free local equipotential bonding

Protection by earth free local equipotential bonding is not applicable.

750:42 Protection against thermal effects

The machine room and the machinery space shall have permanent means of ventilation (preferably forced ventilation) so as to ensure that temperature measured at any point within 1 m of the machinery and associated equipment shall not exceed 40°C.

750:44 Protection against voltage disturbances and electromagnetic disturbances

750:44-3 Protection against overvoltages of atmospheric origin or due to switching

750:44-3.1 Capacitors for power factor improvement, if any, shall be connected to the supply side of the main switch feeding the power circuit. If there is a risk of overvoltage, when for example motors are connected by very long cables, the switch of the power circuit shall also interrupt the connection to the capacitors.

750:44-3.2 Bonding of lift guide rails to a Surge Protective Device (SPD) down conductor shall be permitted. The SPD down conductor shall not be located within the lift well. Guide rails or other well equipment shall not be used as the earthing down conductor for SPD.

750:51 Common rules

750:51-2 Operational conditions and external influences

750:51-2.2 External influences

Electrical equipment shall have at least the following degrees of protection

In machine room, pulley room and machinery space:	IP2X or IPXXB
In lift well, excluding lift pit:	IP54
In lift pit:	IP55

750:51-3 Accessibility

750:51-3.1 Each access door to the machine room or machinery space shall be lockable but it can be opened from inside without the use of a key or a tool.

750:51-3.2 Key of the machine room access door for use in emergency shall be kept in a position near the door in a glass fronted box. Instructions of its use in emergency conditions shall be labelled on the box.

750:51-3.3 The control mechanism for the main switch shall be easily accessible from the access door.

750:51-3.4 There shall be a reasonable access to the control panel. A working space of 75 cm shall be provided in front of the control panel and another space of 60 cm behind it, if it is not wall- mounted, or wherever necessary for servicing.

750:51-4 Identification

750:51-4.1 Notices shall be provided to permit easy identification of the main switch and light switches.

750:51-4.2 The installations shall be provided with the indications necessary to make it easy to understand.

750:51-4.3 If the machine room is common to more than one lift, the control mechanism of each main switch shall be conveniently situated with respect to the lift machine it controls. The notices shall facilitate the identification of the switches appropriate to each lift.

750:51-4.4 Detailed constructions shall be posted concerning the procedure to be followed in the event of breakdown of the lift.

750:51-4.5 Labels, notices and operating instructions shall be legible, durable and readily comprehensible and shall be in both Arabic and English languages.

750:52 Wiring systems

750:52-1 Types of wiring systems

750:52-1.1 Main feeder for supplying power to the lift shall be installed outside the lift well, and shall be of the fire resistant type.

750:52-1.2 In the machine and pulley rooms and lift wells, the conductors and cables (with the exception of traveling cables) shall be of a quality at least equivalent to that defined by SASO 1319, SASO 1449 and SASO 595.

750:52-1.3 Conductors such as those in conformity with SASO 1319 and SASO 1449 shall only be used provided they are installed in conduits (or trunking) made either of metal or plastics or the conductors are protected in an equivalent manner.

750:52-1.4 Rigid cables such as those in conformity with SASO 1450 shall only be used in visible mountings fixed to the walls of the well (or of the machine room, pulley room and machinery space) or installed in ducting, trunking or similar fittings.

750:52-1.5 Ordinary flexible cables such as those in conformity with SASO 595 shall only be used in ducting, trunking or similar fittings.

750:52-1.6 Flexible cables with a thick sheath such as those in conformity with SASO 595 or SASO 1319 may be used like rigid cables in conditions defined in 750:52-1.4, and for connections to a movable appliance (except as traveling cables for connection to the car) or if they are subject to vibrations.

750:52-1.7 The requirements of 750:52-1.2 to 750:52-1.6 need not apply to:

a) conductors or cables not connected to electric safety devices on landing doors, provided that:
   - i) they are not subject to a rated output of more than 100 VA.
   - ii) they are using Extra Low-voltage.

b) the wiring of operating or distribution devices in cabinets or panels:
   - i) either between different pieces of electric equipment, or
   - ii) between these pieces of equipment and the connection terminals.

750:52-1.8 Traveling cables, used for connection to the car, shall be of the extra-flexible type, provided with flame-retardant and moisture-resistant outer cover. For lengths exceeding 30 m, they shall be provided with reinforcement strands. Cables in conformity with EN 50214 and CENELEC HD 360 S2 shall be accepted.

750:52-1.9 Traveling cables between the lift well and lift car terminal boxes shall be suspended by looping over reels or by suitable clamps and terminated at a

suitable position that they will not be prone to damage by water seepage. The connections in the terminal boxes shall be marked for identification purposes.

750:52-2 Selection and erection of wiring systems in relation to external influences

750:52-2.6 Impact

Wiring passing through metal work shall be protected by means of suitable bushes or grummets, securely fixed in position. Every precaution shall be taken to avoid mechanical damage due to sharp edges or abrasive parts.

750:52-2.7 Vibration

Wiring subjected to vibration shall be protected against mechanical damage either by location or by additional protection.

750:52-2.8 Other mechanical stresses

Wiring cables used for door safety circuits or for interconnection between different equipment shall be copper and have a minimum cross-sectional area of 1.5 mm^2.

750:52-6 Electrical connections

750:52-6.1 Connections, connection terminals and connectors shall be located in cabinets, boxes or on panels provided for this purpose.

750:52-6.2 If the cover of the electrical connection box is removable without the aid of a tool, the connections shall be insulated.

750:53 Isolation, switching and control

750:53-3 Devices for protection against overcurrent

750:53-3.1 The overcurrent protective devices for the lift shall be located in the lift machine room.

750:53-3.2 The overcurrent protective devices for the escalator shall be located in the escalator machinery space.

750:53-6.3 Switching-off for mechanical maintenance

750:53-6.3.1 Each lift shall be provided with a main switch in the machine room, located near to its entrance, capable of breaking the supply to the lift on all the live conductors.

750:53-6.3.2 The main switch shall be capable of interrupting the highest current involved in normal conditions of use of the lift.

750:53-6.3.3 The main switch shall not cut the circuits feeding:

- Car lighting or ventilation, (if any);
- Socket-outlet on the car roof;
- Lighting of machine and pulley rooms;
- Socket-outlet in the machine room;
- Lighting of the lift well;
- Alarm devices.

750:53-6.3.4 The main switch shall have stable open and closed positions, and shall be capable of being locked-off in the open position, to ensure no inadvertent operation.

750:53-6.3.5 Each escalator shall be provided with a main switch in the machinery space, located near to its entrance, capable of breaking the supply to the escalator on all the live conductors.

750:53-6.4 **Emergency switching**

750:53-6.4.1 An emergency stop switch for the machinery shall be provided in each machinery space where means of access to the space is provided. A stop switch needs not be provided in a machinery space if the main switch is located therein and close to the machinery.

750:53-6.5 **Functional switching**

750:53-6.5.4 **Motor control**

750:53-6.5.4.1 The opening of the main switch while the lift car is in motion shall cause the machine brake to be applied.

750:53-6.5.4.2 Circuits including 3-phase motors, which are fed through three-phase switches shall be provided with protection against single-phasing or phase-sequence reversal.

750:55 **Other equipment**

750:55-6 **Safety services**

In buildings and structures where standby power is required or furnished to operate a lift, the operation shall be in accordance with 750:55-6.1 though 750:55-6.4.

750:55-6.1 Standby power shall be manually transferable to all lifts in each bank.

750:55-6.2 Where only one lift is installed, the lift shall automatically transfer to standby power within 60 seconds after failure of normal power.

750:55-6.3 Where two or more lifts are controlled by a common operating system, all lifts shall automatically transfer to standby power within 60 seconds after failure of normal power where the standby power source is of sufficient capacity to operate all lifts at the same time. Where the standby power source is not of sufficient capacity to operate all lifts at the same time, all lifts shall transfer to standby power in sequence, return to designated landing and disconnect from standby power source. After all lifts have been returned to the designated level, at least one lift shall remain operable from the standby power source.

750:55-6.4 Where standby power is connected to lifts, the machine room ventilation or air conditioning, if any, shall be connected to the standby power source.

750:55-7 **Socket-outlets**

Socket-outlets, fed independently of the supply of the machine, shall be provided as follows:

- One or more socket-outlets in the machine room, pulley rooms and machinery space. The socket-outlet will be fitted adjacent to the light switch.
- A socket-outlet for servicing in the pit, it shall be protected by a residual current protective device with a rated residual operating current not exceeding 30 mA.
- A socket-outlet on the car roof.

750:55-9 **Luminaires and lighting installations**

750:55-9.1 The machine room, the pulley room, machinery space and lift well shall be provided by permanent lighting which shall be supplied independently of the supply to the machine.

750:55-9.2 Lighting in the machine room, the pulley room and machinery space shall be provided on the basis of at least 200 lux at floor level provided for serving. Lighting switch shall be located at the point of entry.

750:55-9.3 Emergency lights of adequate illuminance for control panels shall be provided in the lift machine room and the machinery space. The illuminance at each control panel shall be not less than 100 lux. These lights shall be operated by batteries and shall be manually operated by a switch located at a convenient position inside the machine room.

750:55-9.4 The lighting in the lift well will comprise one lamp at most 0.5 m from the highest and lowest points in the well with intermediate lamps at 7 m maximum spacing and controlled by two-way switches located in the machine room and in the lift pit. The lighting switch shall be located so as to be readily accessible from the pit access door or the machine room door.

750:55-9.5 Permanent lighting shall be provided to the car on the basis of at least 50 lux at floor level and on the control panels. The car shall be continuously illuminated when the lift is in use. If incandescent lamps, other than spot lights, are used, there shall be at least two connected in parallel. Light bulbs or tubes shall be so guarded as to prevent injury to passengers from their breakage.

750:55-9.6 The car shall have an automatically rechargeable emergency supply of ample capacity to feed an emergency light (normally 1 W lamp) for 1 hour and an emergency alarm signal. This lighting shall come on automatically upon failure of the normal lighting supply.

PART EIGHT

SPECIAL SYSTEMS

CHAPTER 801
POWER FACTOR IMPROVEMENT

801-1 Scope

The chapter of Power Factor Improvement is intended to address the importance of "Power Factor Improvement (PFI)" in the electrical installations, as the presence of low power factor causes high losses in the network, higher transformers ratings, higher circuit breakers ratings and bigger cables sizes. Therefore, in order to have energy conservation and efficient networks, it was found worthy to address this subject and give it high attention. The following statements shall be implied where power factor deemed necessary to be improved. The power factor should not be less than 0.85.

This chapter covers a basic concept about power factor, negative effects of low power factor on electrical installations and advantages of improving power factor.

It also covers suggested methods to avoid bad effects and to achieve benefits through power factor improvement, demonstration of practically used methods in implementing power factor improvement.

The effect of the existing harmonics on voltage and current waveforms and their consequent undesirable effects on the network where power factor improvement capacitors are to be installed is also covered under this chapter.

801-2 Basic concepts of power factor

The power factor of a load, is given by the ratio of the active power (P) to the apparent power (S) i.e. kW divided by kVAR at any given moment. The value of a power factor will range from 0 to 1.

A power factor close to unity means that the reactive energy is small compared with the active energy, while a low value of power factor indicates the opposite condition.

All a.c. equipment and appliances that include electromagnetic devices, or depend on magnetically coupled windings, require some degree of reactive current to create magnetic flux. Table 801-1 shows the average power factor values for various commonly used equipment and appliances.

Power factor may be leading or lagging, depending on the direction of both the active and reactive power flows. If these flows are in the same direction, the power factor at that point of reference is lagging. If either power component flow is in an opposite direction, the power factor at that point of reference is leading, since capacitors and overexcited synchronous motors are a source of reactive power their power factor is always leading.

An induction motor has a lagging power factor as it requires both active and reactive power to flow into the motor (same direction). An overexcited synchronous motor can supply reactive power to the system. The active power component flows into the motor and the reactive power flows into the power system (opposite directions), so the power factor is leading. In an actual power system, the overall system power factor may be lagging, even though some apparatus such as overexcited synchronous motors and capacitors may have a leading power factor.

Table 801-1 Average cosine (φ) and tangent (φ) values for commonly used plants, equipment and appliances.

Plant, equipment and appliances		**cos φ**	**tan φ**
Common induction motor loaded at	0%	0.17	5.80
	25%	0.55	1.52
	50%	0.73	0.94
	75%	0.80	0.75
	100%	0.85	0.62
Incandescent lamps		1.0	0
Fluorescent lamps (uncompensated)		0.40 to 0.50	1.73
Discharged lamps (uncompensated)		0.40 to 0.60	2.29 to 1.33
Lamps (compensated)		>0.85	<0.62
Ovens using resistance elements		1.0	0
Induction heating ovens (compensated)		0.85	0.62
Dielectric type heating ovens		0.85	0.62
Resistance type soldering machines		0.80 to 0.90	0.75 to 0.48
Fixed 1-phase arc-welding set		0.50	1.73
Arc-welding motor-generating set		0.70 to 0.90	1.02 to 0.48
Arc welding transformer-rectifier set		0.70 to 0.80	1.02 to 0.75
Arc furnace		0.8	0.75

801-3 Advantages of power factor improvement

Power factor improvement enhances the power networks in terms of:

- Reduction of the cost of electricity,
- Reduction of cable sizes and panel boards components,
- Reduction of power losses in cables,
- Reduction of voltage drop,
- Increase in available power.

801-4 Selection and erection of power factor improvement equipment

801-4.1 Rated voltage

The rated voltage of the equipment (capacitors in particular) shall be at least equal to the service voltage of the network to which the capacitor is to be connected; account shall be taken of the influence of the presence of the capacitor itself.

In certain networks, a considerable difference may exist between the service and rated voltage of the network, details of which should be furnished by the purchaser, so that due allowance can be made by the manufacturer. This is of importance for equipment, since their performance and life may be adversely affected by an undue increase of the voltage.

801-4.2 Operating temperature

Capacitor banks intended to be used for power factor improvement shall be designed for maximum ambient temperature of 55°C or daily average temperature 45°C.

In exceptional cases, where the maximum ambient temperature may be higher than 55°C, special design capacitors shall be used. Refer to SASO IEC 60831-1 and SASO IEC 60931-1.

801-4.3 Selection

At low voltage, compensation shall be provided by one of the following methods:

801-4.3.1 Fixed value capacitors

This arrangement employs one or more capacitor(s) to form a constant level of compensation. Control choices are as follow:

- Manual: by circuit breaker or load-break switch,
- Semi-automatic: by contactor,

- Direct connection to an appliance and switched with it.

These capacitors are applied in the following conditions:

- At the terminals of inductive devices (motors and transformers),
- At busbars supplying numerous small motors and inductive appliances for which individual compensation would be too costly,
- In cases where the level of load is reasonably constant.

801-4.3.2 Automatically controlled capacitor banks

This type of equipment provides automatic control of compensation, maintaining within close limits, a selected level of power factor.

Such equipment is applied at points in an installation where the active-power and/or reactive-power variations are relatively large, for example:

- At the busbars of a general power distribution board,
- At the terminals of a heavily loaded feeder cable.

801-4.3.3 Synchronous motors

Although synchronous motors are characterized by relatively high losses per kVAR, complicated and costly maintenance, operating noise, etc., they offer:

- Continuous and automatic regulation of the reactive power generated,
- High thermal stability of condenser windings to short circuit currents,
- Repairability.

801-4.3.4 The choice between a fixed or automatically regulated bank of capacitors

Where the kVAR rating of the capacitors is less than, or equal to 15% of the supply-transformer rating, a fixed value of compensation shall be used.

Above the 15% level, automatically controlled bank of capacitors shall be used. The location of low-voltage capacitors in an installation constitutes the mode of compensation, which may be global (one location for the entire installation), partial (section-by-section), local (at each individual device), or some combination of the latter two. In principle, the ideal compensation is applied at a point of consumption and at the level required at any instant. In practice, technical and economic factors govern the choice.

Table 801-2 Rating of the capacitor in kVAR required for an installation

Before Compensation			**kVAR rating of capacitor bank to install per KW of load, to improve cos φ (the power factor) or tan φ , to a given value**												
	Tan f		0.75	0.59	0.48	0.46	0.43	0.40	0.36	0.33	0.29	0.25	0.20	0.14	0.00
Tan f	Cos f		0.80	0.86	0.90	0.91	0.92	0.93	0.94	0.95	0.96	0.97	0.98	0.99	1.00
1.73	0.5		0.982	1.139	1.248	1.276	1.306	1.337	1.369	1.403	1.440	1.481	1.529	1.590	1.732
1.69	0.51		0.937	1.093	1.202	1.231	1.261	1.291	1.324	1.358	1.395	1.436	1.484	1.544	1.687
1.64	0.52		0.893	1.049	1.158	1.187	1.217	1.247	1.280	1.314	1.351	1.392	1.440	1.500	1.643
1.60	0.53		0.850	1.007	1.116	1.144	1.174	1.205	1.237	1.271	1.308	1.349	1.397	1.458	1.600
1.56	0.54		0.809	0.965	1.074	1.103	1.133	1.163	1.196	1.230	1.267	1.308	1.356	1.416	1.559
1.52	0.55		0.768	0.925	1.034	1.063	1.092	1.123	1.156	1.190	1.227	1.268	1.315	1.376	1.518
1.48	0.56		0.729	0.886	0.995	1.024	1.053	1.084	1.116	1.151	1.188	1.229	1.276	1.337	1.479
1.44	0.57		0.691	0.848	0.957	0.986	1.015	1.046	1.079	1.113	1.150	1.191	1.238	1.299	1.441
1.40	0.58		0.655	0.811	0.920	0.949	0.979	1.009	1.042	1.076	1.113	1.154	1.201	1.262	1.405
1.37	0.59		0.618	0.775	0.884	0.913	0.942	0.973	1.006	1.040	1.077	1.118	1.165	1.226	1.368
1.33	0.6		0.583	0.740	0.849	0.878	0.907	0.938	0.970	1.005	1.042	1.083	1.130	1.191	1.333
1.30	0.61		0.549	0.706	0.815	0.843	0.873	0.904	0.936	0.970	1.007	1.048	1.096	1.157	1.299
1.27	0.62		0.515	0.672	0.781	0.810	0.839	0.870	0.903	0.937	0.974	1.015	1.062	1.123	1.265
1.23	0.63		0.483	0.639	0.748	0.777	0.807	0.837	0.870	0.904	0.941	0.982	1.030	1.090	1.233
1.20	0.64		0.451	0.607	0.716	0.745	0.775	0.805	0.838	0.872	0.909	0.950	0.998	1.058	1.201
1.17	0.65		0.419	0.576	0.685	0.714	0.743	0.774	0.806	0.840	0.877	0.919	0.966	1.027	1.169
1.14	0.66		0.388	0.545	0.654	0.683	0.712	0.743	0.775	0.810	0.847	0.888	0.935	0.996	1.138
1.11	0.67		0.358	0.515	0.624	0.652	0.682	0.713	0.745	0.779	0.816	0.857	0.905	0.966	1.108
1.08	0.68		0.328	0.485	0.594	0.623	0.652	0.683	0.715	0.750	0.787	0.828	0.875	0.936	1.078
1.05	0.69		0.299	0.456	0.565	0.593	0.623	0.654	0.686	0.720	0.757	0.798	0.846	0.907	1.049
1.02	0.7		0.270	0.427	0.536	0.565	0.594	0.625	0.657	0.692	0.729	0.770	0.817	0.878	1.020
0.99	0.71		0.242	0.398	0.508	0.536	0.566	0.597	0.629	0.663	0.700	0.741	0.789	0.849	0.992
0.96	0.72		0.214	0.370	0.480	0.508	0.538	0.569	0.601	0.635	0.672	0.713	0.761	0.821	0.964
0.94	0.73		0.186	0.343	0.452	0.481	0.510	0.541	0.573	0.608	0.645	0.686	0.733	0.794	0.936
0.91	0.74		0.159	0.316	0.425	0.453	0.483	0.514	0.546	0.580	0.617	0.658	0.706	0.766	0.909
0.88	0.75		0.132	0.289	0.398	0.426	0.456	0.487	0.519	0.553	0.590	0.631	0.679	0.739	0.882
0.86	0.76		0.105	0.262	0.371	0.400	0.429	0.460	0.492	0.526	0.563	0.605	0.652	0.713	0.855
0.83	0.77		0.079	0.235	0.344	0.373	0.403	0.433	0.466	0.500	0.537	0.578	0.626	0.686	0.829
0.80	0.78		0.052	0.209	0.318	0.347	0.376	0.407	0.439	0.474	0.511	0.552	0.599	0.660	0.802
0.78	0.79		0.026	0.183	0.292	0.320	0.350	0.381	0.413	0.447	0.484	0.525	0.573	0.634	0.776
0.75	0.8		0.000	0.157	0.266	0.294	0.324	0.355	0.387	0.421	0.458	0.499	0.547	0.608	0.750
0.72	0.81			0.131	0.240	0.268	0.298	0.329	0.361	0.395	0.432	0.473	0.521	0.581	0.724
0.70	0.82			0.105	0.214	0.242	0.272	0.303	0.335	0.369	0.406	0.447	0.495	0.556	0.698
0.67	0.83			0.079	0.188	0.216	0.246	0.277	0.309	0.343	0.380	0.421	0.469	0.530	0.672
0.65	0.84			0.053	0.162	0.190	0.220	0.251	0.283	0.317	0.354	0.395	0.443	0.503	0.646
0.62	0.85			0.026	0.135	0.164	0.194	0.225	0.257	0.291	0.328	0.369	0.417	0.477	0.620
0.59	0.86			0.000	0.109	0.138	0.167	0.198	0.230	0.265	0.302	0.343	0.390	0.451	0.593
0.57	0.87				0.082	0.111	0.141	0.172	0.204	0.238	0.275	0.316	0.364	0.424	0.567
0.54	0.88				0.055	0.084	0.114	0.145	0.177	0.211	0.248	0.289	0.337	0.397	0.540
0.51	0.89				0.028	0.057	0.086	0.117	0.149	0.184	0.221	0.262	0.309	0.370	0.512
0.48	0.9				0.000	0.029	0.058	0.089	0.121	0.156	0.193	0.234	0.281	0.342	0.484

801-4.3.5 Assessment of kVAR rating of capacitors

The rating of the capacitor required for an installation is shown in table 801-2.

The same value may be derived from the formula:

$kVAR = kW * (\tan \varphi_1 - \tan \varphi_2)$

801-4.3.6 Self-excitation of induction motors

Self-excitation is a known phenomenon which can be raised if an induction motor is compensated by a capacitor bank, and the motor has a high-inertia load at its axis, where the capacitor bank along with the decaying EMF induced in the stator windings create an increasing stator current and consequently the voltage at the terminals of the motor increases sometimes to dangerously high levels; there is a tendency to spontaneously (and uncontrollably) self-excite.

In order to avoid self-excitation as described above, the kVAR rating of the capacitor bank shall be limited to the following maximum value:

$$Q_c \leq \sqrt{3} \text{ x } 0.9 \text{ x } I_o \text{ x } U_n$$

Where

I_o the no-load current of the motor and,

U_n phase-to-phase nominal voltage of the motor in kV.

Table 801-3 gives appropriate values of Q_c corresponding to this criterion. However, since the values of the table are, in general, too small, then additional compensation of the motor to the level of cos φ normally required. Additional compensation, such as overall bank shall be installed for global compensation of a number of smaller appliances.

In any installation where high-inertia motor-driven loads exist, the circuit breakers or contactors controlling such motors should, in the event of total loss of power supply, be rapidly tripped.

The protection scheme for these motors shall therefore include an over voltage and reverse power tripping relays.

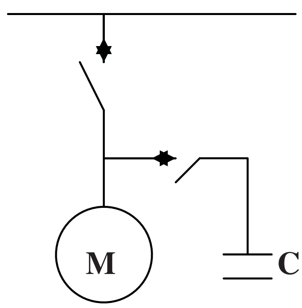


Figure 801-1 connection of the capacitor bank to the motor

If the capacitor bank associated with a high-inertia motor is larger than that recommended in table 801-3, then it shall be separately controlled by a circuit breaker or contactor, which trips in unison with the main motor-controlling circuit breaker or contactor, as shown in figure 801-1.

Closing of the main contactor is commonly subject to the capacitor contactor being previously closed.

NOTE 1 Exact sizing of capacitor unit for a particular motor is only possible when the "no-load current" or "no-load magnetizing" kVAR is known.

NOTE 2 It is recommended that special motors should not to be compensated; such as:

- Reversing, stepping, inching and plugging motors.
- Motors that are restarted while still running and generating substantial back voltage.
- Cranes or elevator motors where the load may drive the motor; or on multi-speed motors.

- Open-transition reduced-voltage starters that are used with wye-delta connections and capacitors.
- Capacitors should be connected on the line side of contactors involved in any open-circuit transition for voltage change or speed.

Table 801-3 Maximum kVAR of PF improvement applicable to motor terminals without risk of self-excitation.

3-phase motors 220/380 V					
Nominal power		KVAR to be installed			
		Speed of rotation (RPM)			
KW	hp	3600	1800	1200	900
22	30	5	6.7	7.5	8.3
30	40	6.3	8.3	9.2	10.4
37	50	7.5	9.2	10.4	13.3
45	60	9.2	10.8	11.7	14.2
55	75	10.8	14.2	15	17.5
75	100	14.2	18.3	20.8	23.3
90	125	16.7	20.8	22.5	25
110	150	20	24.2	27.5	30.8
132	180	25.8	30	31.7	35.8
160	218	29.2	34.2	36.7	43.3
200	274	35.8	39.2	44.2	50.8
250	340	43.3	47.5	52.5	59.2
280	380	47.5	52.5	58.3	65.8
355	55.8	55.8	63.3	71.7	81.7
400	544	65	68.3	80.8	88.3
450	610	72.5	77.5	89.2	97.5

801-4.3.7 Selection of capacitor specifications

The specifications of capacitors shall be chosen according to the presence harmonics generating devices as addressed in 801-5.2.

801-4.4 Erection of equipment

801-4.4.1 Global compensation

Where a load is continuous and stable, global compensation can be applied. In this case, the capacitor bank shall be connected to the busbars of the main LV distribution board for the installation as shown in figure 801-2, and remains in service during the period of normal load.

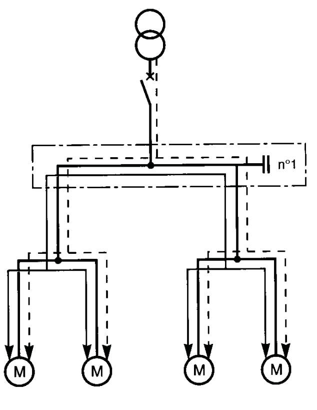


Figure 801-2 Global compensation

A. Advantages

- Reduces the tariff penalties for excessive consumption of kVARs,
- Reduces the apparent power kVA demand, on which standing charges are usually based,
- Relieves the supply transformer, which is then able to accept more load if necessary.

B. Disadvantages

- Reactive current still flows in all conductors of cables leaving (i.e. downstream of) the main LV,
- distribution board,
- For the above reason, the sizing of these cables, and power losses in them, are not improved by the _____________
- global mode of compensation.

801-4.4.2 Compensation by section

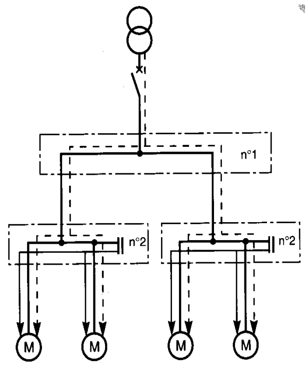


Figure 801-3 Compensation by section

Compensation by section is recommended when the installation is extensive, and where the load/time patterns differ from one part of the installation to another. In this case, capacitor banks shall be connected to busbars of each local distribution board, as shown in figure 801-3.

A. Advantages

- Reduces the tariff penalties for excessive consumption of kVARs,
- Reduces the apparent power kVA demand, on which standing charges are usually based,
- Relieves the supply transformer, which is then able to accept more load if necessary,
- The size of the cables supplying the local distribution boards may be reduced, or will have additional capacity for possible load increases,
- Losses in the same cables will be reduced.

B. Disadvantages

- Reactive current still flows in all cables downstream of the local distribution boards,
- For the above reason, the sizing of these cables, and the power losses in them, are not improved by compensation by sector,
- Where large changes in loads occur, there is always a risk of overcompensation and consequent over voltage problems.

801-4.4.3 Individual compensation

Individual compensation should be considered when the power of motor is significant with respect to the power of the installation. In this case, capacitors shall be connected directly to the terminals of inductive components (i.e. motors as shown in figure 801-4. Individual compensation should be considered when the

power of the motor is significant with respect to the declared power requirement (kVA) of the installation.

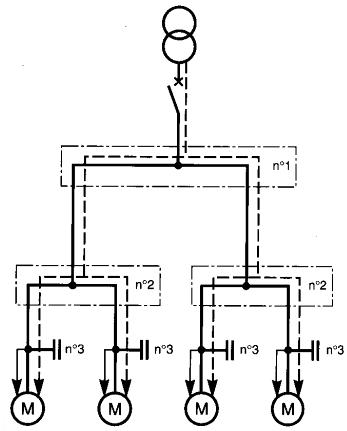


Figure 801-4 Individual compensation

Capacitor bank in this case shall be connected directly to motor at one of the following locations:

- after the overload relay,
- before the overload relay, or
- at the starter.

The first case may be used for new installations, as the motor overload relay can be selected at the time of purchase on the basis of the reduced line current due to the capacitors.

Second case may be preferred for existing installations, as no change in the overload relay is required because the current through the overload relay is the motor current.

Third case may be used when capacitors are permanently connected to the system. Its main advantage is the elimination of a separate switching device for the capacitors.

A. Advantages

- Reduces the tariff penalties for excessive consumption of kVARs,
- Reduces the apparent power kVA demand,
- Reduces the size of all cables as well as the cable losses.

B. Disadvantages

- excessive inrush current or reclosing,
- transient torques,
- over voltage due to self-excitation.

NOTE Capacitors can materially increase the motor time constant, which influences the safe time for reconnecting the motor-capacitor combination to the line. The effect of slow decay of voltage in motors due to capacitors may have harmful effects where high-speed reclosing is used. In such cases reclosing should be delayed.

801-4.4.4 Connection of a capacitor bank and protection settings

801-4.4.4.1 Effect on protection settings

Since after applying compensation to a motor, and the current to the motor and capacitor combination will be lower than before, assuming the same motor-driven load conditions, as shown in figure 801-5.

The rating of overcurrent protection devices of the motor which are located upstream of the motor-capacitor connection shall be decreased.

The line current reduction may be approximated from the following expression:

$$\Delta I = I\,(1 - \cos\varphi 1 \;/\; \cos\varphi 2)$$

Where
ΔI line current reduction
cos φ1 power factor before installation of capacitor
cos φ2 power factor after installation of capacitor

before compensation **after compensation**

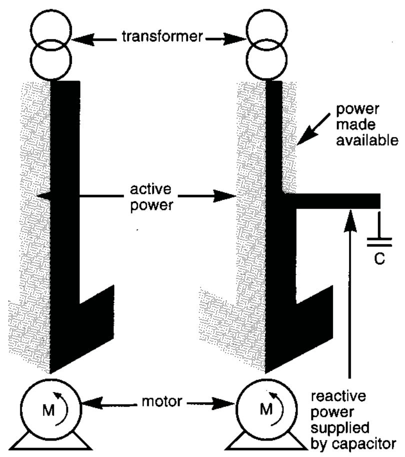


Figure 801-5 Before compensation, the transformer supplies all the reactive power; after compensation, the capacitor supplies a large part of the reactive power

For motors compensated in accordance with the kVAR values indicated in table 801-3 (maximum values recommended for avoidance of self-excitation of standard induction motors, as discussed in 801-4.3.6, the above-mentioned ratio will have a value similar to that indicated for the corresponding motor speed in table 801-4.

Table 801-4 Reduction factor for over current protection after compensation

Speed in RPM	Reduction factor
900	0.73
1200	0.75
1800	0.76
3600	0.78

801-4.4.4.2 Switching and protective devices and connections

The switching and protective devices and the connections shall be designed to carry continuously a current of 1.3 times the current that would be obtained with a sinusoidal voltage of an r.m.s. value equal to the rated voltage the rated frequency due to the possible presence of harmonic current. As the capacitor may have a capacitance equal to 1.5 times the value corresponding to its rated output, this current may have a maximum value of 1.3 x 1.15 times the rated current (manufacturer tolerances).
Moreover, harmonic components, if present, may have a greater heating effect than the corresponding fundamental component, due to skin effect.
The switching and protective devices and the connections shall be capable of withstanding the electrodynamic and thermal stress caused by the transient over currents of high amplitude and frequency that may occur when switching on.
Such transients are to be expected when a capacitor (unit or bank) is switched in parallel with other capacitor(s) that are already energized. It is common practice to

increase the inductance of the connections in order to reduce switching current, although this increases the total losses. Care should be taken not to exceed the maximum permissible switching current.

When consideration of the electrodynamic and thermal stresses would lead to excessive dimensions, special precautions, such as those mentioned in SASO IEC 60831-1 for the purpose of protection against over currents, should be taken.

NOTE 1 Fuses, in particular, should be chosen with adequate thermal capacity (see SASO IEC 60269-2 and SASO IEC 60931-3).

NOTE 2 In certain cases, for example when the capacitors are automatically controlled, repeated switching operations may occur at relatively short intervals of time. Switchgear and fuses should be selected to withstand these conditions.

NOTE 3 Breakers connected to the same busbars, which is also connected to a bank of capacitors may be subjected to special stressing the event of switching on a short circuit.

NOTE 4 Breakers for switching of parallel banks shall be able to withstand the inrush current (Amplitude and frequency) resulting when one bank is connected to busbar to which other bank(s) are already connected.

It is recommended that capacitors be protected against over current by means of suitable over current relays, which are adjusted to operate the circuit breakers when the current exceeds the permissible limit specified. Fuses do not generally provide suitable over current protection.

NOTE 1 Depending on the design of the capacitors, their capacitance will vary more or less with temperature.

NOTE 2 Attention should be paid to the fact that the capacitance may change rapidly after the energization of cold capacitors. This may cause needless functioning of the protective equipment.

NOTE 3 If iron cored reactors are used, attention should be paid to possible saturation and overheating of the core by harmonics.

NOTE 4 Any bad contacts in capacitor circuits may give rise to arcing caused high frequency oscillations that may overheat and overstress the capacitors. Regular inspection of all capacitor equipment contacts is therefore recommended.

801-5 Effects of harmonics

801-5.1 Resonance

The installation of capacitors (in which the impedances are predominantly inductive) can, however, result in total or partial resonance occurring at one of the harmonic frequencies.

The following expression may be used to determine the potential of harmonic resonance with a capacitor bank for radial system:

$$h = \sqrt{\text{kVA SC} / \text{kVAR C}}$$

Where

h	order of the harmonic
kVA SC	short-circuit duty
kVAR C	capacitor bank rating

for example if (h) value is taken as 2.93, which shows that the natural frequency of the capacitor/system-inductance combination is close to the 3rd harmonic frequency of the system.

From h = f / 60 it can be seen that

f = 60 x h = 60 x 2.93 = 175.8 Hz

The closer a natural frequency approaches one of the harmonics present on the system, the greater will be the undesirable effect.

In the above example, strong resonant conditions with the 3rd harmonic component of a distorted wave would certainly occur.

In such cases, steps shall be taken to change the natural frequency to a value, which will not resonate with any of the harmonics known to be present. This is

achieved by the addition of a harmonic-suppression inductor connected in series with the capacitor bank. On 60 Hz systems, these reactors are often adjusted to bring the resonant frequency of the combination, i.e. the capacitor bank and reactors to 228 Hz.

These frequencies correspond to a value for h of 3.8 for a 60 Hz system, i.e. approximately mid-way between the 3rd and 5th harmonics.

In this arrangement, the presence of the reactor increases the fundamental-frequency current by a small amount (7-8%) and therefore the voltage across the capacitor in the same proportion.

This feature is taken into account, for example, by using capacitors, which are designed for about 10% over the applied voltage.

801-5.2 Selection of capacitor specification

A choice is made from the following parameters:

- Gh = the sum of the kVA ratings of all harmonic-generating devices (static converters, inverters, speed controllers, etc.) connected to the busbars from which the capacitor bank is supplied.
- If the ratings of some of these devices are quoted in kW only, assume an average power factor of 0.7 to obtain the kVA ratings.
- kVA sc = the 3-phase short-circuit level in kVA at the terminals of the capacitor bank.
- Sn = the sum of the kVA ratings of all transformers supplying (i.e. directly connected to) the system level of which the busbars form a part.

From these parameters, a choice of capacitor specification, which will ensure an acceptable level of operation with the system harmonic voltages and currents, can be made, by reference to the table 801-5.

Table 801-5 Choice of solutions for limiting harmonics associated with an LV capacitor bank

Capacitors supplied at LV via transformer(s)			
General rule valid for any size of transformer(s)			
Gh $\leq$ kVA sc / 120	kVA sc / 120 $\leq$ Gh $\leq$ kVA sc / 70	Gh > kVA sc / 70	
Standard capacitors	Capacitor voltage rating increased by 10% (except 230 V units)	Capacitor voltage rating increased by 10% + harmonic suppression reactor	
Simplified rule if transformer(s) rating Sn $\leq$ 2 MVA			
Gh $\leq$ 0.15 Sn	0.15 Sn < Gh $\leq$ 0.25 Sn	0.25 Sn < Gh $\leq$ 0.60 Sn	Gh > 0.60 Sn
Standard capacitors	Capacitor voltage rating increased by 10% (except 230 V units)	Capacitor voltage rating increased by 10% + harmonic suppression reactor	filters

801-6 Verification

801-6.1 Verification of installation

Each bulky installation such as industrial plants, commercial buildings and residential compounds, where high power plants, such as central air conditioning, are installed, the installation shall be subject to tests in order to verify that power factor is not less than 0.85. Such verification shall be made on periodic basis in order to assure that the installation is still at healthy status.

801-6.2 Verification of capacitors

Tests of capacitors employed for the sake of power factor improvement shall be conducted in accordance with SASO IEC 60931, SASO IEC 60831 and SASO IEC 61921.

Annex A.801
(informative)

A.801-1 Examples

The following are few examples on how to assess the kVAR rating of the capacitors, methods of Power Factor Improvement and harmonic – suppression.

A.801-1.1 Example on assessment of kVAR rating of the capacitors

It is required to improve the power factor of a 666 kVA installation from 0.75 to 0.93.
The active power demand is:

666 x 0.75 = 499.5 kW.

In table 805-2, the intersection of the row cos φ = 0.75 (before correction) with the column cos φ = 0.93 (after correction) indicates a value of 0.487 kVAR of compensation per kW of load.
For a load of 499.5 kW, therefore,

499.5 x 0.487 = 243.26 kVAR of capacitive compensation is required.

A.801-1.2 Examples on methods of Power Factor Improvement

Example – 1

Refer to Figure A.801-1.
An installation is supplied from a 630 kVA transformer loaded at 450 kW (P1) with a mean power factor of 0.8 lagging.

The apparent power S1 = $\frac{450}{0.8}$ = 562.5 kVA

The corresponding reactive power

$Q_1 = \sqrt{S_1^2 - P_1^2}$ = 337.5 kVAR

The anticipated load increase P2 = 100 kW at a power factor of 0.7 lagging.

The apparent power S2 = $\frac{100}{0.7}$ = 143 kVA

The corresponding reactive power

$Q_2 = \sqrt{S_2^2 - P_2^2}$ = 102 kVAR

What is the minimum value of capacitive kVAR to be installed, in order to avoid a change of transformer?
Total power now to be supplied:

P = P1 + P2 = 550 kW.

The maximum reactive power capability of the 630 kVA transformer when delivering 550 kW is:

$Q\,m = \sqrt{S^2 - P^2}$

$Q\,m = \sqrt{630^2 - 550^2}$ = 307 kVAR

Total reactive power required by the installation before compensation:

Q1 + Q2 = 337.5 + 102 = 439.5 kVAR.

So that the minimum size of capacitor bank to install:

Q kVAR = 439.5 - 307 = 132.5 kVAR.

It should be NOTED that this calculation has not taken account of peak loads and their duration.
The best possible improvement, i.e. correction which attains a PF of 1 would permit a power reserve for the transformer of 630 - 550 = 80 kW. The capacitor bank would then have to be rated at 439.5 kVAR.

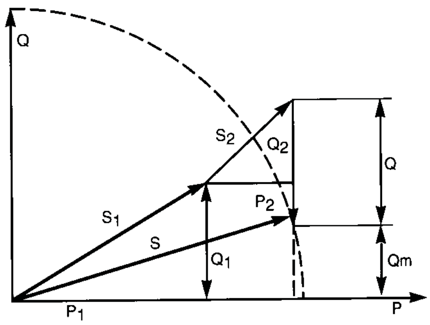


Figure A.801-1 Compensation Q allows the installation-load extension S2 to be added, without the need to replace the existing transformer, the output of which is limited to S.

Example – 2

Installation before PFI	**Installation after PFI**
kVA; kW; kVAR - kVARh are billed heavily above the declared level - apparent power kVA is significantly greater than the kW demand. - the corresponding excess current causes losses (kWh) which are billed $\overrightarrow{KVA} = \overrightarrow{kW} + \overrightarrow{kVAR}$ (vector quantities)	kW; kVA - the consumption of kVAR is either eliminated or reduced, according to the cos φ required - the tariff penalties ° for reactive power where applicable ° for the entire bill in some cases - the installation must be over dimensioned are eliminated - the fixed charge based on kVA demand is adjusted to be close to the active power kW demand
630 kVA 13.8 kV/380–220 V - characteristics of the installation 500 kW cos φ = 0.75 - transformer is overloaded - the power demand (apparent power) is S = P/ cos φ = 500 / 0.75 = 667 kVA	630 kVA 13.8 kV/380–220 V - characteristic of the installation 500 kW cos φ = 0.928 - transformer no longer overloaded - the power demand is 539 kVA - there is 14% spare transformer capacity available
x - the current flowing into the installation downstream of the circuit breaker is $I = P / \sqrt{3}\ U \cos \varphi = 1013$ A	x - the current flowing into the installation through the circuit breaker is 819 A
- Losses in cables are calculated as a function of the current squared $(1013)^2$ $P = I^2 R$	- the losses in the cables are reduced to $(819 / 1013)^2 = 65\%$ of the former value, thereby economizing in kWh consumed
- cos φ = 0.75 - reactive power is supplies through the transformer and via the installation wiring. - the transformer, circuit breaker and cables must be over dimensioned.	- cos φ = 0.928 - reactive power is supplied by the capacitor bank kVAR Capacitor bank rating is 250 kVAR in 5 automatically controlled steps of 50 kVAR.
Vertical and Horizontal LPS Conductors	R cos φ = 0.928 workshop

A.801-1.3 Examples on harmonic – suppression

Three cases are presented, showing respectively situations in which standard, over dimensioned, and over dimensioned plus harmonic-suppression-equipped capacitor banks should be installed.

Example 1:

500 kVA transformer having 4% short-circuit voltage.
Total rating of harmonic-generating devices
Gh = 50 kVA
kVA sc = 500 x 100 / 4 = 12,500 kVA
kVA sc / 120 = 12,500 / 120 = 104
Gh = 50 $\leq$ kVA sc / 120
Solution: use standard capacitors.

Example 2:

1,000 kVA transformer having 6% short-circuit voltage.
Total rating of harmonic-generating devices
Gh = 220 kVA
kVA sc = 1,000 x 100 / 6 = 16,667 kVA
kVA sc / 120 = 16,667 / 120 = 139
kVA sc / 70 = 16,667 / 70 = 238
Gh = 220 is between kVA sc / 120 and kVA sc / 70
Solution: use overrated capacitors.

Example 3:

630 kVA transformer having 4% short-circuit voltage.
Total rating of harmonic-generating devices
Gh = 250 kVA
kVA sc = 630 x 100 / 4 = 15,750 kVA
kVA sc / 70 = 15,750 / 70 = 225
Gh = 250 > kVA sc / 70
Solution: use overrated capacitors and harmonic-suppression reactors.

CHAPTER 802
PROTECTION AGAINST LIGHTNING

802-1 Scope and object

Lightning is a natural hazardous phenomenon, being the discharge to earth of static electricity generated in parts of storm clouds. Thousands of flashes strike the ground per year; some of them damage buildings and/or kill or injure people and animals either directly or indirectly by causing fire and explosions.

As the current is discharged through the resistance of the earth electrodes of a lightning protection system, it produces a momentarily high voltage relative to true earth. It may also produce around the earth electrodes a high potential gradient dangerous to people and animals.

Lightning protection system designed and installed in accordance with this chapter reduces significantly the risk of damage caused by lightning, but cannot guarantee absolute protection to building, persons or objects.

Access to ground and proper use of foundation steelwork for the purpose of forming an effective earth termination may well be impossible once construction work on a site has commenced. Therefore, soil resistivity and the nature of the earth should be considered at the earliest possible stage of a project. This information is fundamental to the design of an earth termination system, which may influence the foundation design work of architects. To avoid unnecessary work, regular consultation between lightning protection system designer, architects and builder is essential.

802-1.1 Scope

This chapter applies to the design and installation of lightning protection system (LPS) for common buildings up to 60 m high used for ordinary purposes, whether commercial, industrial, farming, institutional or residential. Moreover, some recommendations and provisions are given in 802-6 of this chapter for buildings higher or having parts higher than 60 m.

The following cases are outside the scope of this chapter:

a) Telecommunication systems external to a building;
b) Railway systems and watercrafts;
c) Electric generating, transmission, and distribution systems external to a building;
d) Vehicles, ships, aircrafts, and offshore installations.

This chapter does not apply to the protection of electrical installations from voltage surges of atmospheric origin transmitted through the distribution system, it does not either cover the protection of sensitive equipment installed inside buildings and which require additional protective measures; relevant protection and measures are defined in Chapter 53.

802-1.2 Object

This chapter establishes whether or not a building needs a lightning protection system (LPS). It provides the necessary information concerning design, construction and materials to facilitate the management and basic installation of an effective LPS of the buildings indicated in 802-1. It gives fundamental principles related to the selection of such system and its components ensuring the safeguarding of persons and property. It also gives basic requirements and instructions for good and satisfactory inspection practice of LPS.

802-2 Lightning parameters

Lightning parameters are usually obtained from measurements taken on high objects. The statistical distribution of the recorded lightning parameters can be assumed to have a logarithmic normal distribution. On this basis, the probability of occurrence of any value of each parameter can be calculated from the values given in annex A of SASO 1614.

The polarity ratio of lightning strokes depends on the nature of the region in the Kingdom; however the values reported in this chapter are based on 10% positive and 90% negative.

802-2.1 Lightning current parameters

The mechanical and thermal effects of lightning are related to the peak value of the current (I), the total charge (Q_{total}), the impulse charge ($Q_{impulse}$) and the specific energy (W/R). The highest values of these parameters occur in positive flashes

The damaging effects caused by induced voltage are related to the steepness of lightning current front, in this chapter the average steepness between 30% and 90% values of the peak current is recommended for design purposes.

Table 802-1 below gives values of lightning parameters related to the protection levels.

Table 802-1 Relationship of lightning current parameters to protection levels

Lightning parameter		Protection level		
		I	II	III – IV
Current peak value	I (Ka)	200	150	100
Total charge	Q_{total} (C)	300	225	150
Impulse charge	$Q_{impulse}$ (C)	100	75	50
Specific energy	W/R (kJ/Ω)	10000	5600	2500
Average steepness	kA/μs	200	150	100

802-2.2 Lightning ground flash density:

The lightning ground flash density expressed in terms of ground strokes per square kilometer per year may be determined by measurements.

If lightning ground stroke density (Ng) is not available, it shall be estimated by using the following formula:

$$N_g = 0.04\ T_d^{\ 1.25} \qquad \text{flashes per km}^2 \text{ per year}$$

Where T_d is the number of thunderstorm days per year, characters the region where the building is located.

NOTE 1 This number Td is in general, published by the Presidency of Meteorology and Environment according to the meteorology stations in the different regions and towns of the Kingdom.

NOTE 2 In the absence of recorded values, this number is considered equal to 10 as average.

802-3 Selection of protection levels for lightning protection system

The purpose of selecting a protection level is to reduce, below the maximum tolerable level, the risk of damage caused by a direct lightning flash to a building, or to a volume to be protected.

For each building the risk of damage can be estimated taking into account the annual frequency of direct lightning flashes (N_d), the probabilities of building being struck by lightning, these probabilities involve in particular the height of the building, its method of construction, its location, and the nature and altitude of the ground upon which it is built. The damage depends on several parameters, among which are: the use and the content (human and goods) of the volume to be protected; construction materials and measures taken to reduce the consequential effects of lightning. Buildings are classified according to the consequential effects of lightning as indicated in SASO 1614.

802-3.1 Accepted frequency N_c of lightning flashes to a building

The tolerable values of the acceptable lightning frequency (N_c) may be calculated by the following formula:

$$N_c = \frac{1.5 \times 10^{-3}}{C} \qquad \text{Where } C = C1.C2.C3.C4.C5$$

The values of C1, C2, C3, C4 and C5 are obtained from tables 802-2 through 802-6 below.

Table 802-2 Determination of building environmental coefficient C1

Relative building location	Coefficient C1
Building located within a space containing buildings, trees or metallic poles of the same height or taller within a distance not longer than 3H	0.25
Building surrounded by smaller buildings in height within a distance not longer than 3H	0.5
Isolated building, no other buildings are located near it within a distance of 3H	1.0
Isolated building on hilltop	2
NOTE H being the total height of the building	

Table 802-3 Determination of building type coefficient C2

Building Coefficient C2			
Roof			
Structure	**Metal**	**Nonmetal**	**Flammable**
Metal	0.5	1.0	2.0
Nonmetal	1.0	1.0	2.5
Flammable	2.0	2.5	3.0

Table 802-4 Determination of building content coefficient C3

Building Content Coefficient	
Building Contents	**Coefficient C3**
Low value and nonflammable	0.5
Standard value and nonflammable	1.0
High value, moderate flammability	2.0
Exceptional value, flammable	3.0
Computer or electronics	4.0
Exceptional value, irreplaceable	4.0
Vulnerable cultural buildings	4.0

Table 802-5 Determination of building occupancy coefficient C4

Building Occupancy Coefficient	
Building Occupancy	**Coefficient C4**
Unoccupied	0.5
Normally occupied	1.0
Difficult to evacuate or risk of panic	3.0

Table 802-6 Determination of building consequence coefficient C5

Lightning Consequence Coefficient	
Lightning Consequence	**Coefficient C5**
Continuity of facility services not required, no environmental impact	1.0
Continuity of facility services required, no environmental impact	5.0
Consequences to the environment	10.0

Some common types of consequences of lightning strokes to several types of buildings are indicated below:

- For private homes: risk of fire limited to objects close to lightning strike,
- For farms: risk of fire and dangerous sparks, power failure and loss of ventilation & food distribution,
- For theaters, schools, large stores, sports areas, mosques: risk of panic and fire, alarm and power systems failure,
- For banks, hospitals and elderly care, public buildings: panic, egress problems, alarm and power failure, and loss of computer,
- For industrial buildings: loss of production, loss of feed stock, equipments damage, explosion of explosive materials,
- For museums and cultural sites: Irreparable losses of cultural heritage.

802-3.2 Expected frequency Nd of direct lightning flashes to a building

The average annual frequency N_d of direct lightning flashes to a building shall be calculated from the following formula:

$$N_d = N_g A_e 10^{-6}$$

In which,

N_d is the annual lightning strike frequency to the building;

N_g is the average annual ground flash density, in lightning flashes per square kilometer per year;
in the region where the building is located (see 802-2.2)

A_e is the equivalent collection area of the building (m^2).

The equivalent collection area of a building A_e is defined as an area of ground surface, which has the same annual frequency of direct lightning flashes as the building.

The equivalent collection area A_e of a building is, for isolated buildings, the area enclosed within the border line obtained from the intersection between the ground surface and a straight line with 1:3 slope which passes from the upper parts of the building and rotating around it, A_e shall be calculated using the following formula for a buildings in flat country:

$$A_e = ab + 6h(a + b) + 9\pi\pi^2$$

Where*:*

"a" is the building length (m);

"b" is the building width (m);

"h" is the building height (m).

NOTE For the calculation of the equivalent collection area A_e for buildings in hilly country and for buildings in presence of surrounding objects refer respectively to Figure 2 and Figure 3 of SASO 1614.

802-3.3 Procedure for selection of the lightning protection system

The accepted lightning frequency N_c shall be compared with the expected lightning frequency Nd, the result of this comparison is used as follow to decide if a lightning protection is needed:

- If $N_d \leq N_c$ a lightning protection system is not needed;
- If $N_d > N_c$ a lightning protection system of efficiency $E \geq 1 - N_c / N_d$ shall be installed and the proper level of protection shall be selected according to table 802-7 below:

Table 802-7 Lightning level of protection efficiency related to the protection level

Protection level	Lightning protection efficiency
I	98 %
II	95 %
III	90 %
IV	80 %

Design, installation and materials of the decided lightning protection system shall fully comply with the provisions of this chapter and meet especially the requirements given for the selection of the protection level.

802-4 Planning and installation of LPS

802-4.1 Planning procedure

The designer of the LPS shall evaluate the lightning risk of the building and decide whether or not an LPS is needed. If it is needed, the proper level of protection should be selected.

LPS design and selection procedure requires an adequate assessment of the building under consideration according to its features, dimensions and localization;

thunderstorm activity (annual lightning flash density) in the considered region of the Kingdom and the building classification.

NOTE Detailed explanation of LPS selection and design is given in annex A.802.

802-4.2 LPS components

The principal components of a lightning protection system are specified in the following 802-4.2.1 to 802-4.2.4.

802-4.2.1 Air termination system

802-4.2.1.1 General

The probability of a lightning stroke penetrating the space to be protected is considerably decreased by the presence of properly designed air-termination system.

The air-termination systems can be composed of any combination of the following elements:

- rods;
- stretched wires;
- meshed conductors.

802-4.2.1.2 Positioning

The arrangement of the air-termination system is adequate if the requirements of table 802-8 have been fulfilled. In the design and installation of an air-termination system, the following methods may be used independently or in any combination:

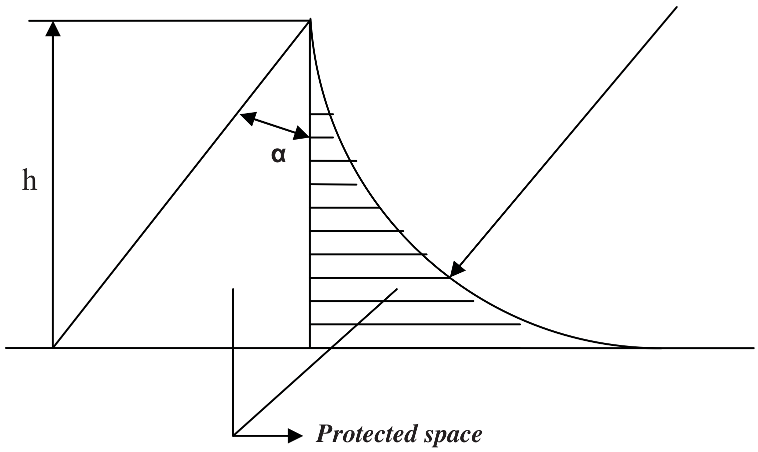
- Protective angle method, suitable for simple buildings or small parts of buildings having complex geometry;
- Rolling sphere method, suitable for complex shaped buildings;
- Mesh size method which is for general purpose and particularly suitable for plane surfaces.

NOTE Further information on the methods and the relationship between air-termination positioning and protection levels are given in annex A.802.2.1 and SASO IEC 61024-1-2.

Table 802-8 Positioning of air-termination according to the level of protection

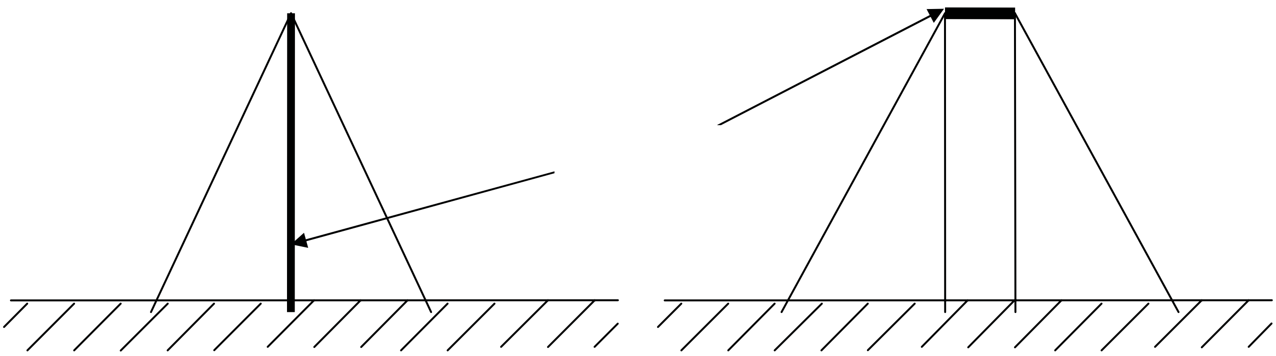
Protection Level	h (m) / R (m)	20	30	45	60	Mesh width (m)
		α^0	α^0	α^0	α^0	
I	20	25	*	*	*	5
II	30	35	25	*	*	10
III	45	45	35	25	*	15
IV	60	55	45	35	25	20

** Rolling sphere and mesh methods only apply in these cases.*



h is the height of the air termination above the surface to be protected.
R is the radius of the rolling sphere
α is the protective angle of the conic space in degrees

The protected area of an LPS single vertical or horizontal conductor of an air-termination system according to the protective angle method is shown in figure 802-1.



One Vertical conductor **One Horizontal conductor**

Figure 802-1 Plan views of zone of protection at ground level of one vertical and one horizontal conductor

802-4.2.1.3 Construction

For isolated LPS the distance between the air-termination system and any metal installation within the space to be protected shall be greater than the safety distance according to 802-4.3.3.

In the case of an LPS not isolated from the space to be protected, the air-termination system shall be installed directly on the roof providing that damage will not be caused by the effect of the lightning current.

NOTE 1 For more details on isolated LPS see examples of figures B.802-1 and B.802-2 in annex B.802.

NOTE 2 For more details on non-isolated LPS see examples of figures B.802-3 in annex B.802.

802-4.2.1.4 Natural components

The following parts of a building may be considered as "natural" air-termination components:

a) metal sheet covering the space to be protected, provided that the electrical continuity between the various parts is made durable, and the thickness of the metal sheet is not less than 4 mm if it is Fe, 5 mm if it is Cu and 7 mm if it is Al;

b) metal components of roof construction, underneath non-metallic roofing, provided that this latter part can be excluded from the space to be protected;

c) metal pipes and tanks, provided that they are constructed of material not less than 2.5 mm thick and they will not create any danger.

802-4.2.2 Down-conductors

802-4.2.2.1 General

In order to reduce the possibility of occurrence of dangerous sparking, the down conductors are to be arranged in such a way that from point of strike to earth:

a) several parallel current paths exist;

b) the length of the current paths is kept to a minimum.

The down conductors shall be so arranged that they become, as far as possible, the direct continuation of the air-termination conductors.

802-4.2.2.2 Positioning for isolated LPS

If the air-termination of an isolated LPS (see figure 802-2) consists of rods on separate masts (or one mast), at least one down conductor is needed for each mast. In case of masts made of metal or interconnected reinforcing steel, no additional down conductor is necessary.

If the air-termination consists of separate horizontal conductors (or one conductor), at least one down conductor is needed at each conductor end.

If the air termination forms a network of conductors, at least one down conductor is needed for each supporting structure.

802-4.2.2.3 Positioning for not-isolated LPS

When down conductors are distributed around the perimeter of the space to be protected in such a way that the average value of the distance between them is not more than the values indicated in table A.802-1. At least two down conductors are necessary in all cases.

NOTE 1 The average value of the distance between don conductors is correlated with the safety distance in 802-4.4.3, If these values are greater than those specified in table 802-9, the safety distances should be considerably increased.

NOTE 2 An equal spacing of the down conductors is preferred around the perimeter. A down conductor should be near to each corner of the building where this is possible.

Down conductors shall be interconnected by means of horizontal ring conductors near ground level and by further rings at 20 m intervals vertically.

802-4.2.2.4 Construction

For isolated LPS, the distance between the down conductor system and the metal installations of the space to be protected shall be grater than the safety distance according to 802-4.4.3.

Down conductors of LPS not isolated from the space to be protected may be installed as follow:

- if the wall is made of non-combustible material the down conductors may be positioned on the surface or in the wall;

- if the wall is made of flammable material, the down conductors can be positioned on the surface of the wall, provided that their temperature rise due to the passage of lightning current is not dangerous for the material of the wall;
- if the wall is made of flammable material and the temperature rise of down conductors is dangerous, the down conductors shall be placed in such a way that the distance between them and the space to be protected is always greater than 0.1 m. Mounting brackets made of metal may be in contact with the wall.

Down conductors shall be installed straight and vertical such that they provide the shortest, most direct path to earth. The formation of loops shall be avoided.

802-4.2.2.5 Natural components

The following parts of the building may be considered "natural" down conductors:

a) Metal installations provided that:
  - the electrical continuity between the various parts is made durable according to the requirements of sub-clause 2.4.2 of SASO 1614;
  - their dimensions are at least equal to that specified for standard down conductors.

b) the metal frame work of the building;

c) the interconnected steel of the building.

NOTE the horizontal ring conductors may be not necessary if the metal frame-work of steel structures or the interconnected reinforcing steel of the building is used as the down conductors.

802-4.2.2.6 Test joint

At the connection of the earth termination a test joint should be fitted on each down conductor, except in the case of "natural" down conductors. The joint should be capable of being opened with the aid of a tool for measuring purposes, but normally it should be closed.

NOTE For more details on down conductors recommended numbers and spacing, refer to A.802.3 in annex A.802.

802-4.2.3 Earth termination system

802-4.2.3.1 General

In order to disperse the lightning current into earth without causing dangerous over-voltages, the shape and dimensions of the earth termination system are more important than a specific value of the resistance of the earth electrode. However, in general, a low earth resistance is recommended.

Earth termination systems (i.e. lightning protection, low-voltage, power systems, telecommunication systems) should be connected to the integrated by equipotential bonding in accordance with 802-4.4.2.

NOTE Serious corrosion problems can occur when connecting to each other earthing systems utilizing different materials.

802-4.2.3.2 Earth electrodes

The following types of earth electrodes should be used: one or more ring electrodes, vertical (or inclined) electrodes, radial electrodes or a foundation earth electrode.

Plates and small earth lattice mats (mesh) are optional but shall be avoided when possible due to the possibility of corrosion, especially at the joints.

A number of properly distributed conductors is preferred to a single long earth conductor. Deep-driven earth electrodes are, however, effective where the soil resistivity decreases with depth.

802-4.2.3.3 **Earthing arrangements**

For earth termination systems, two basic types of earth electrode arrangements apply:

- type A arrangement consisting of radial or vertical earth electrodes. Each down conductor shall be connected to at least one separate earth electrode composed of either a radial or vertical (or inclined) electrode.
- type B arrangement consisting of ring earth electrode (or foundation earth electrode), the mean radius r of the area enclosed by the ring earth electrode shall be not less than the values given in sub-clause 2.3.3.2 of IEC 61024-1.

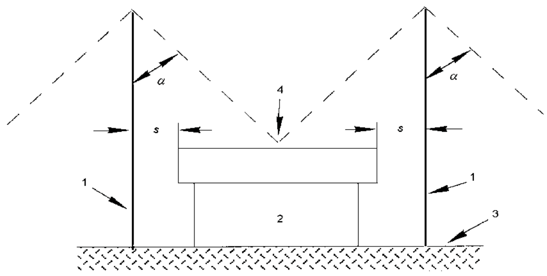


Figure 802-2 (a) Projection on vertical reference plane

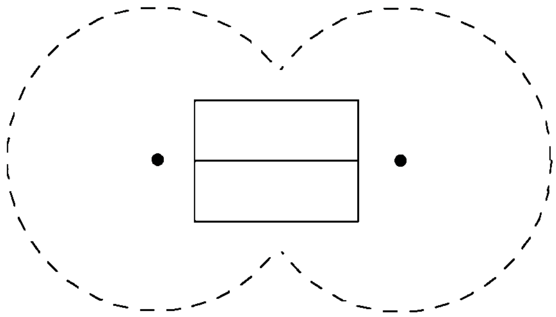


Figure 802-2 (b) Projection on horizontal reference planes

1 - Air-termination mast
2 - Protected structure
3 - Reference plane
4 - Intersection between protective cones
s - Separation distance according to 802-4.4.3
α - Protective angle complying with table 802-8

NOTE: The two circles denote the protected area on the reference plane.

Figure 802-2 Example of an isolated LPS using two isolated air-termination masts

802-4.3 Installation

802-4.3.1 General

Any part of a lightning protection system that is subject to mechanical damage or displacement shall be securely fixed and protected with a protective molding or covering.

NOTE If metal pipe or tubing is used around the conductor, the conductor shall be electrically connected to the pipe or tubing at both ends.

802-4.3.2 Air terminals

802-4.3.3 Down conductors

802-4.3.3.1 Down conductors shall be installed straight and vertical such that they provide the shortest, most direct path to earth.

802-4.3.3.2 Down conductors must be secured by at least 3 fasteners per linear meter, fastener must be appropriate for the supporting medium and installed so as no not to impair water tightness and allow the conductor to expand.

802-4.3.4 Earth electrodes

802-4.3.4.1 The external ring earth electrodes should preferably be buried at a depth of at least 0.7 m but not closer than 1.0 m to the building walls, they should be distributed as uniformly as possible to minimize electrical coiling effects in the earth.

802-4.3.4.2 Embedded depth and type of the earth electrodes shall be such as to minimize the effects of corrosion, soil drying and freezing and thereby stabilize the equivalent earth resistance.

802-4.3.5 Clamping and joints

Air terminations and down conductors shall be firmly fixed in accordance with requirements of table 802-9 so that electrodynamic or accidental mechanical forces will not cause conductors to break or loose.

Table 802-9 Recommended fixing centers for conductors

Arrangement	Fixing Centers (mm)
Horizontal conductors on horizontal surfaces	1000
Horizontal conductors on vertical surfaces	500
Vertical conductors	1000
Vertical conductors over 20 m length	750
Vertical conductors over 25 m length	500
NOTE This table does not apply to built-in type fixings, which may require special consideration.	

802-4.4 Sparking prevention

Lightning strikes may give rise to harmful potential differences between LPS conductors and other grounded metal bodies and wires belonging to the building; these potential differences, caused by resistive and inductive effects, can be of such a magnitude that dangerous flashing over or sparking can easily occur. In order to reduce the possibility of flashing over, and avoid this problem, following methods may be used:

802-4.4.1 Isolated LPS

An isolated LPS by insulating or separation (see the example of figure 802-2) should be used when the flow of lightning current into bonded internal conductive parts may cause damage to the building.

NOTE 1 When the thermal effects on the point of strike or on conductors carrying the lightning current may cause damage to the building or to the content of the volume to be protected, the spacing between isolated LPS conductors and dangerous material should be at least 1.5 m.

802-4.4.2 Bonding grounded metal bodies

802-4.4.2.1 All metallic projections on or above the main surface of the roof witch are connected, intentionally or fortuitously to the general mass of the earth should be bounded to, and form part of, the air termination network (interconnected to provide a common ground potential). This shall include roof coverings, windows washing equipment, electric service, telephone and antenna, metallic piping systems including water service, well casings, gas piping, underground conduits, and underground liquefied petroleum gas piping systems. Conductors bonding metal installations don't carry a significant part of lightning current; their minimum dimensions should comply with table 802-13 of 802-5.2.

802-4.4.2.2 Equipotential bonding shall be carried out at the following locations:

a) In the basement or approximately at ground level. Bonding conductors shall be connected to a bonding bar constructed and installed in such a way that it allows easy access for inspection. For large buildings more than one bonding bar could be installed provided that they are interconnected.

b) Above ground at vertical intervals not exceeding 20 m for buildings of more than 20 m in height. Bonding bars shall be connected to the horizontal ring conductors, which bond the down conductors.

c) Where safety distance requirements are not fulfilled.

802-4.4.2.3 For isolated LPS, equipotential bonding shall be established only at ground level.

802-4.4.2.4 If electric, community antenna television (CATV), data, telephone, or other systems are bonded to a metallic water pipe; only one connection from the lightning protection system to the water pipe system shall be required provided that the water pipe is electrically continuous between all systems.

802-4.4.2.5 If the water pipe is not electrically continuous due to the use of plastic flange or other reasons, a surge suppressor (diverter) should be placed across the flange or the nonconductive sections shall be bridged with main size conductors or the connection shall be made at a point where electrical continuity is ensured.

802-4.4.2.6 Surge suppressors where required, shall be installed in such a way that they can be inspected.

802-4.4.2.7 Where metal bodies located within a steel-framed structure are inherently bonded to the structure through the construction, separate bonding connections shall not be required.

802-4.4.2.8 Metal antenna masts or supports located on a protected structure shall be connected to the lightning protection system using main size conductors and listed fittings unless they are within a zone of protection.

802-4.4.3 Safety distance

When equipotential bonding cannot be achieved, a separation distance S between the lightning conductors and the surrounded metallic bodies as well as between extraneous conductive parts and lines shall be allowed, distance beyond which no dangerous sparks can be produced between the conductors carrying the lightning current and nearby metallic networks. This distance shall be increased above the safety distance "d" which is calculated according to following formula:

$$s \geq d$$

$$d = k_i \frac{k_c}{k_m} l$$

Where:

k_i depends on the selected protection level of LPS as it is given in table 802-10

k_c depends on dimensional configuration; it is determined according to the number of down conductors:
(k_c = 1 for 1 down conductor, k_c = 0.66 for 2 down conductors, k_c = 0.44 for 3 or more down conductors).

k_m depends on separation material (see table 802-11)
(k_m = 1 for air , k_m = 0.52 for solid material other than metal).

l is the vertical distance between the point at which proximity is measured and the point at which the metallic networks is earthed or the nearest equipotential bonding points.

NOTE For the safety distance applied to a cantilevered part of a structure see requirements on figure B.802-3.

Because it is often difficult to guarantee that lightning protection system is sufficiently isolated during installation or will remain so in the event of building changes, on site work, equipotential bonding is often preferred. There are, however, some cases in which equipotential bonding is not used (e.g. when there are flammable or explosive piping network). Here down conductors are routed beyond the safety distance "S".

Table 802-10 Proximity of installations to LPS, Values of coefficient ki

Protection level	k_i
I	0.1
II	0.075
III	0.05
IV	0.05

NOTE The most important safeguard against life hazard in the space to be protected is the equipotential bonding.

Table 802-11 Proximity of installations to LPS, Values of coefficient km

Separation Material	k_m
Air	1.0
Solid	0.52

802-4.4 Sensitive systems protection

Lightning strikes may introduce severe transient voltages into electronic equipment inside the building, these surges depend not only on the lightning protection of the building itself but also on the installation details of the wiring and sensors and the route to the electronic equipment in the building. For the protection of the sensitive equipments against these transient surges, surge protective devices (SPD) as specified in Chapter 55 should be fitted as close as possible to the point of entry/exit to the building.

802-5 Selection and installation of LPS materials

802-5.1 Type of materials

802-5.1.1 The materials used shall withstand the electric and electromagnetic effects of the lightning current and predictable accidental stress without being damaged.

802-5.1.2 Lightning protection systems shall be made of materials that are resistant to corrosion or acceptably protected against corrosion.

802-5.1.3 Combinations of materials that form electrolytic couples of such a nature that in the presence of moisture corrosion is accelerated shall not be used.

802-5.1.4 Copper lightning protection materials shall not be installed on aluminum roofing, siding, or other aluminum surfaces.

802-5.1.5 Aluminum lightning protection materials shall not be installed on copper surfaces.

802-5.1.6 Precautions shall be taken to provide the necessary protection against any potential deterioration of any lightning protection component due to local conditions.

802-5.1.7 Components of LPS may be manufactured from the materials listed in table 802-12, provided that they have sufficient electrical conductivity and corrosion resistance. Other metals may be used if they possess equivalent mechanical, electrical and chemical performances.

802-5.2 Dimensions

802-5.2.1 Air terminal height shall be not less than 300mm above the object or area it is to be protected.

802-5.2.2 Air terminals shall be placed vertically at the highest and most vulnerable points on the building and arranged at regular intervals around the periphery of the roof.

802-5.2.3 The number of air terminals needed is determined according to the zone of protection requirements but at any case the distance between two 300 mm air terminals should not exceed 10 m and the distance between two 500 mm air terminals should not exceed 15 m.

802-5.2.4 Metal roof fixtures, not protected by air-termination rods, don't require additional protection if their dimensions do not exceed the following:

a) Height above the roof level 1.0 m;

b) The total area of the superstructure 1.0 m^2.

802-5.2.5 Minimum dimension of LPS conductors, including the air termination conductors, down conductors and earth termination conductors, for different materials such as copper, aluminum and iron are given in following Tables 802-13, 802-14 and 802-15.

Table 802-12 LPS materials and conditions of use

Material	Use			Corrosion		
	In open air	In earth	In Concrete	Resistance	Increased by	Electrolytic with
Copper	Solid stranded as coating	Solid stranded as coating	-	Against many materials	Highly concentrated chlorides sulphur compounds Organic materials	-
Hot galvanized steel	Solid stranded	Solid	Solid	Good, even in acid soils	-	Copper
Stainless steel	Solid stranded	Solid	-	Against many materials	Water with dissolved chlorides	-
Aluminum	Solid stranded	-	-	-	Basic agents	Copper
Lead	Solid as coating	Solid as coating	-	High concentration of sulphates	Acid soils	Copper

Table 802-13 Minimum dimensions of LPS materials

Protection level	Material	Air-termination (mm^2)	Down-conductor (mm^2)	Earth-termination (mm^2)
I to IV	Cu	35	16	50
	Al	70	25	-
	Fe	50	50	80

Table 802-14 Minimum dimensions for bonding conductors carrying a substantial part of lightning current

Protection level	Material	Air-termination (mm^2)
I to IV	Cu	16
	Al	25
	Fe	50

Table 802-15 Minimum dimensions for bonding conductors carrying no significant part of lightning current

Protection level	Material	Air-termination (mm^2)
I to IV	Cu	6
	Al	10
	Fe	16

802-5.3 Requirements for sports stadiums

Large numbers of people are often in attendance in sports stadiums, for their protection against any direct lightning flash strikes, the following additional measures of protection shall be taken:

- With the advent of high multi-tier stands, air terminations in the form of horizontal wires could be strung across the stadium from one side to the other. Bonding of all metal parts would need to be performed in accordance with the recommendations of this chapter.
- Another possibility would be to make use of the floodlighting towers, either as essential elements of the lightning protection system or as supports for horizontal wires or vertical rods. In either case provision would need to be made to protect people from danger by direct contact with the towers or against ground voltage stress around their bases. Direct contact with the tower, could be prevented by sheathing with a protective insulating material from ground level to a height of about 3 m or by fencing off the tower base and restricting access to it. Reduction of the ground stress to a level, which would not cause harm to people, which depends upon the average soil resistivity and the earthing arrangements, is necessary.

802-6 LPS requirements for buildings exceeding 60 m in height

802-6.1 General requirements

802-6.1.1 Common buildings exceeding 60 m in height and used for ordinary purposes whether commercial, industrial, farm, institutional, or residential shall be protected with materials having the minimum dimensions indicated in table 802-16.

802-6.1.2 If parts of a building exceeds 60 m in height and the remaining portion does not exceed this height, the requirements for air terminals and conductors shall apply only to that portion exceeding 60 m in height.

Table 802-16 Minimum LPS material requirements for buildings exceeding 60 m in height

LPS component		Cooper	Aluminium
Type of conductor	**Parameter**	**Size**	**Size**
Air terminals, solid	Diameter	18 mm	20 mm
Down conductors, (cable)	Diameter Cross section	- 35 mm^2	- 50 mm^2
Air termination conductors, (cable)	Diameter Cross section	- 50 mm^2	- 70 mm^2
Main conductor, solid strip (Roof & Down conductors)	Thickness Width	2.0 mm 25 mm	3 mm 25 mm
Bonding conductor, cable (solid or stranded)	Diameter Cross section	- 50 mm^2	- 70 mm^2
Bonding conductor (solid strip)	Thickness Width	2.0 mm 25 mm	3 mm 25 mm

802-6.2 Non-conducting structures

On non-conducting structures, at least two equally spaced down conductors should be provided and it should be ensured, using the rolling sphere method, that the air termination gives the desired zone of protection.

802-6.3 Conducting structures

Where a building contains electrically continuous metal, this metal may be used as a component of the LPS, but where down conductors are needed, not less than two should be installed and spaced not more than 10 m apart around the perimeter.

802-6.4 Minarets, Towers and spires

Lighting strikes below the highest points of tall buildings are well authenticated and not less than two down conductors should be provided for all minarets, towers and spires.

For non-conducting buildings, an air termination network should be designed to follow the construction contours of a tower; flagpoles and any other salient features above parapet level should also be included in the system. The reminder of a minaret should be protected in accordance with this chapter, with ridge, eaves and down conductors, earth termination networks and lightning protection potential equalization. Metal roofs may be suitable for use as air termination networks.

NOTE For additional information on LPS for high buildings (over 60m) see information given in chapter 3 of NFPA 780.

802-7 Verification

For visual inspection and testing refer to chapter 61.

NOTE: Guides for inspection and testing LPS available in Annex F.61.

Annex A.802
Lightning Protection System Design

A.802-1 Planning procedure

The primary function of an LPS designed according to this chapter is to protect lives and property from the destructive effects of lightning. For this, designer should obtain information regarding the function, construction and location of the building; classify the structure, determine whether or not it needs an LPS, and select the proper protection level. The flow diagram shown in figure A.802-1 indicates the planning procedure that should followed to design a rational LPS ensuring the protection the building and its surroundings against lightning.

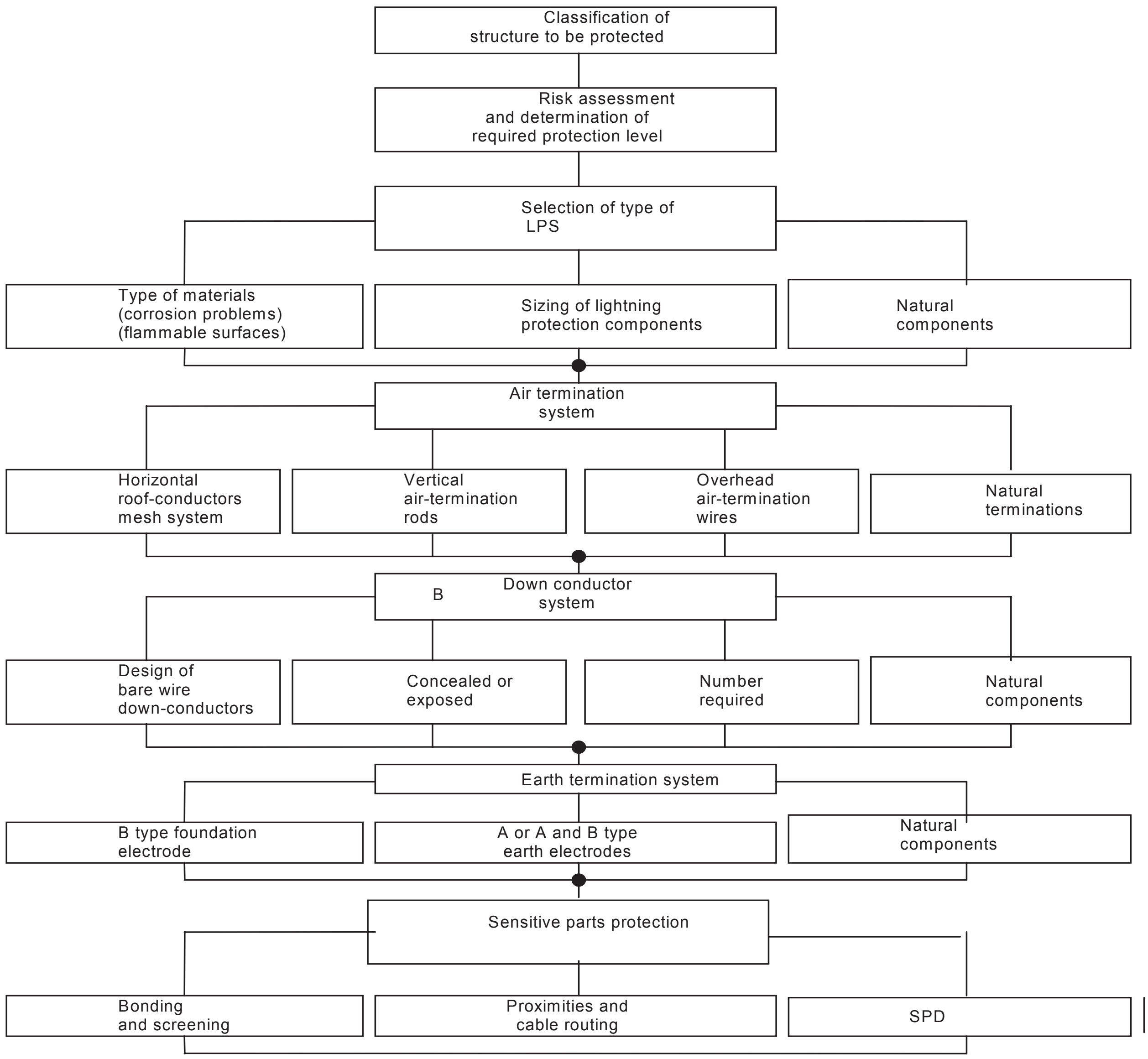


Figure A.802-1 LPS planning procedure

A.802-2 **LPS component parts:**

A lightning protection system consists in general of the following principal interconnected component parts:

- Air terminations;
- Down Conductors;
- Earth terminations;
- Earth electrodes.

A.802-2.1 **Air termination system design**

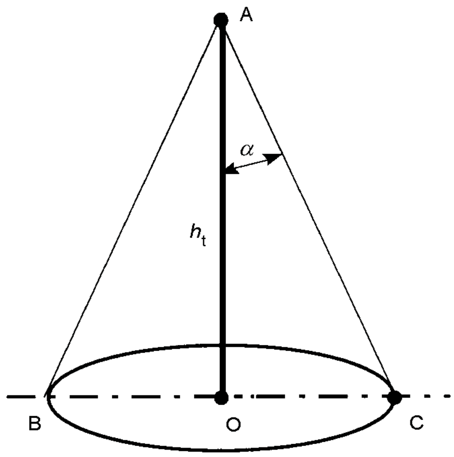
Air termination system consists of vertical or horizontal conductors or combinations of both; the probability of a lightning stroke penetrating the space to be protected is considerably decreased by the presence of a properly designed air-termination system. For the design of an air-termination system the following methods should be used, independently or in any combination, provided that the zone of protection afforded by different parts of the air-termination overlap and ensure that the building is entirely protected:

- Protective angle method, suitable for simple buildings or small parts of buildings having complex geometry;
- Rolling sphere method, suitable for complex shaped buildings;
- Mesh size method which is for general purpose and particularly suitable for plane surfaces.

A.802-2.1.1 **Protective angle method**

Air-termination conductors, rods, masts and wires, should be positioned so that all parts of the structure to be protected are inside the envelope surface generated by projecting points on the air-termination conductors to the reference plane, at an angle α to the vertical in all directions.

A single point A generates a cone, figures A.802-2, A.802-3 and A.802-4 show protected space generated by different LPS air-termination conductors.



A - Tip of an air termination
B - Reference plane
OC - Radius of protected area
h_t - Height of an air termination rod above the reference plane
α - Protective angle

Figure A.802-2 Protected space within the cone generated by a single tip of air-termination rod

The protective angle method has geometrical limits and shall not be applied if h is larger than the rolling sphere radius R as defined in table 802-8.

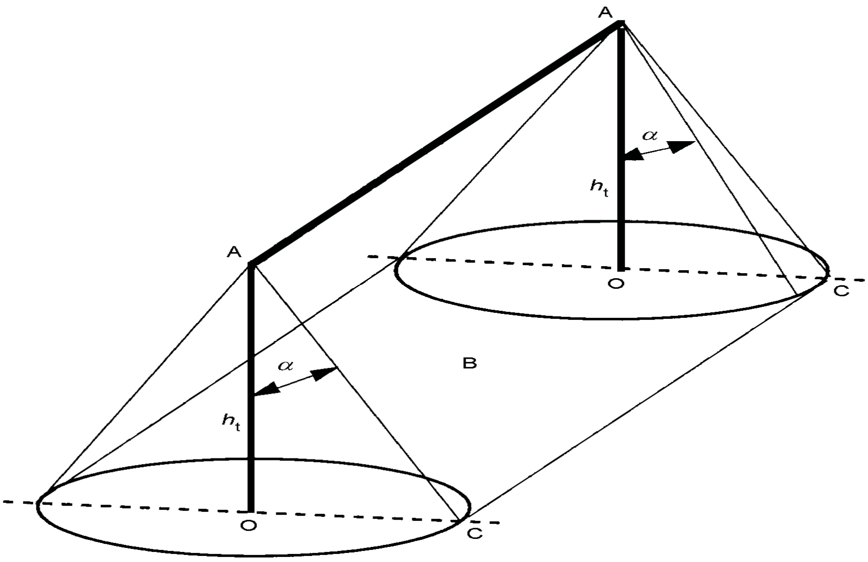
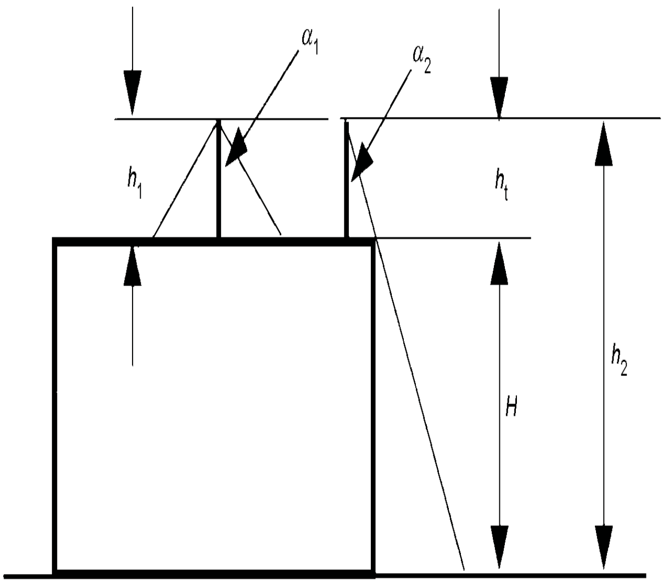


Figure A.802-3 Protected space generated by a horizontal air-termination conductor

NOTE For legend see figure A.802-1.



H - is the physical height of an air-termination rod.

NOTE The protective anglea1 α_1 corresponds to the air termination height h = h1, being the height above the rod surface to be measured (reference plane); the protective angle α_2 corresponds to the height h2=h1+H, being the soil reference plane.

Figure A.802-4 Protective angle method air-termination design for different heights

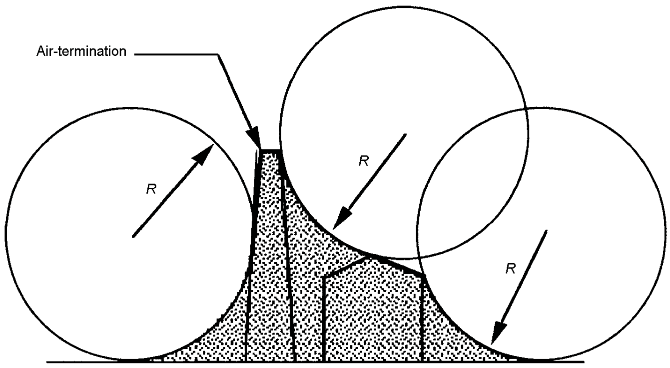
The protective angle α should comply with table 802-8, h being the height of the air-termination above the surface to be protected. According to this table, the protective angle α is different for different heights of air-termination above the surface to be protected.

A.802-2.1.2 Rolling sphere method

Rolling sphere method appropriate for buildings having complex geometry should be used to identify the protected space of parts and areas of a building when table 802-8 excludes the use of the protective angle method. Applying this method, the positioning of an air-termination system is adequate if no point of the space to be protected is in contact with a sphere with radius R rolling on the ground, around and on to top of the building in all possible directions. Therefore the sphere shall touch only the ground and/or the air-termination system.

The radius of the rolling sphere should comply with the selected protection level of the LPS according to the table 802-8.

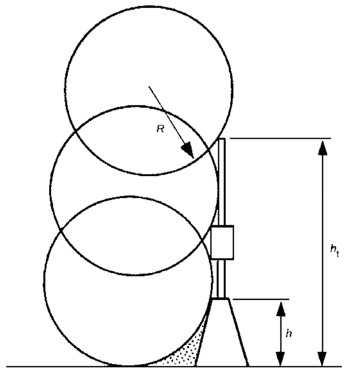
Figures A.802-5, A.802-6 and A.802-7 show the application of the rolling sphere method to different buildings. The sphere of radius R is rolled around and over all the building until it meets the ground plane or any permanent building or object in contact with the earth plane, which is capable of acting as a conductor of lightning. Where the rolling sphere touches the building, a strike could occur and at such points protection by an air-termination conductor is required.



R - Radius of the rolling sphere according to table 802-8

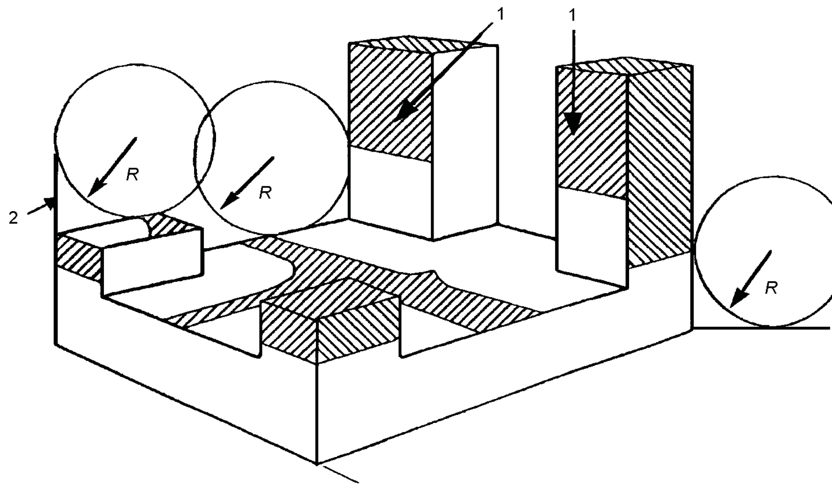
NOTE Air termination LPS conductors are installed on all points and segments, which are in contact with the rolling sphere, whose radius complies with the selected protection level.

Figure A.802-5 Design of an LPS air-termination according to the rolling sphere method



R - Radius of the rolling sphere
H_t - Physical height of the tower, mast and air-termination rod
H - Height of air termination as used in table 802-8

Figure A.802-6 Design of an LPS on a tower using the rolling sphere method

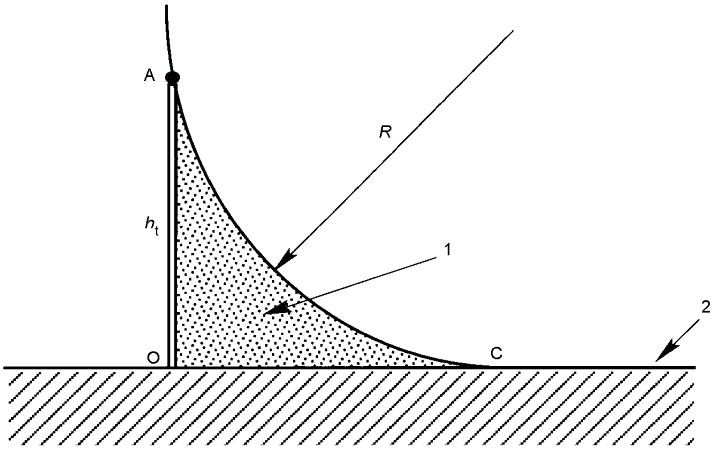


1 - See NOTE
2 - Mast on the building
R - Radius of the rolling sphere

NOTE Shaded areas (1) are exposed to lightning interception and need protection according to table 802-8.

Figure A.802-7 Design of an LPS air termination conductor network on a complicated shape building

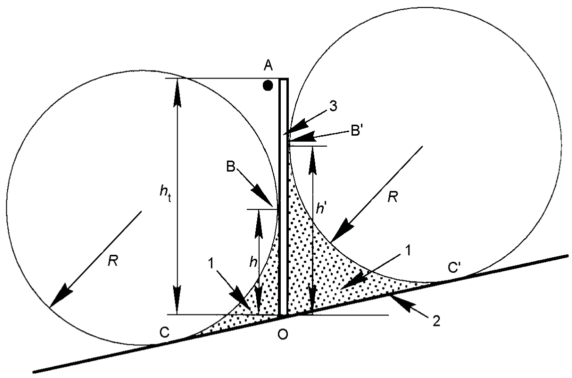
When the rolling sphere method is applied to drawings of the building, the building should be considered from all directions to ensure that no part protrudes into an unprotected zone, a point which might be overlooked if only front, side and plan views on drawings are considered.
The protected space generated by an LPS conductor is the volume not penetrated by the rolling sphere when it is in contact with the conductor and applied to the building.
Figure A.802-8 shows the protection afforded by an air-termination rod or mast with a physical height, ht = h, which is less than the radius R of the rolling sphere or a point A on an LPS horizontal air-termination conductor at a physical height, ht = h, from the plane of reference.



1 - Protected space
2 - Reference plane
R - Radius of the rolling sphere
OC - Radius of the protected area
A - Point on a horizontal air termination conductor
h_t - h as indicated in table 802-8, physical height of the air termination conductor above the reference plane

Figure A.802-8 Protected space of an air termination rod, mast or horizontal conductor (h_t< R)

When the applied height h, in table 802-8, is greater than rolling sphere radius R the protection afforded by the air-termination rod or point on a horizontal air-termination conductor is restricted to the building below point B as indicated in figure A.802-9.
Another horizontal air-termination conductor should be placed at level B and an air-termination is required at point C if it is a part of the building to be protected.



1 - Protected space
2 - Reference plane
3 - Air-termination rod
R - Radius of the rolling sphere according to table 802-8
h, h' - Heights of air-termination according to table 802-8
h_t - Physical height of air termination above the reference plane
A - Point on a horizontal air-termination conductor
B, C, B', C' - Touching points with the rolling sphere

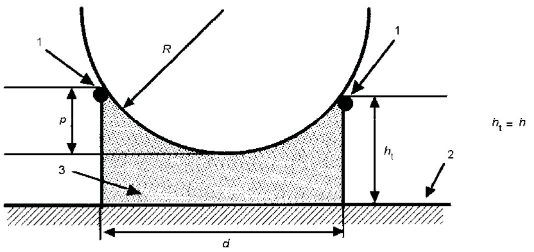
NOTE The heights h and h' shall be less than h_t. Two values of h, e.g. h and h' are applicable on a sloped reference plane.

Figure A.802-9 Protected space of an air-termination rod, mast or horizontal wire at A (h_t < R)

In the case of two parallel horizontal LPS air-termination conductors placed above the horizontal reference plane in figure A.802-10, the penetration distance p of the rolling sphere below the level of the conductors in the space between the conductors should be calculated:

$$p = R - [R^2 - (d/2)^2]^{1/2}$$

The penetration distance p shall be less than h_t.



1 - Space protected by two parallel air-termination horizontal wires or two air-termination rods
2 - Reference plane
3 - Whole protected area
h_t - Physical height of the air-termination rods above the reference plane
p - Penetration distance of the rolling sphere
h - Height of the air termination according to table 802-8
R - Radius of the rolling sphere
d - Distance separating two parallel air-termination horizontal wires or two air-termination rods

NOTE: The penetration distance p of the rolling sphere shall be less than ht to protect the whole area, between the terminations.

Figure A.802-10 Space protected by tow parallel air termination horizontal rods (h_t < R)

A.802-2.1.3 Mesh method (Faraday cage)

For the purpose of protecting flat buildings, a mesh is considered to protect the whole surface if the following conditions are fulfilled:

a) Air termination conductors are positioned on:
- roof edge lines,
- roof overhangs,
- roof ridge lines, if the roof slope exceeds 1/10;

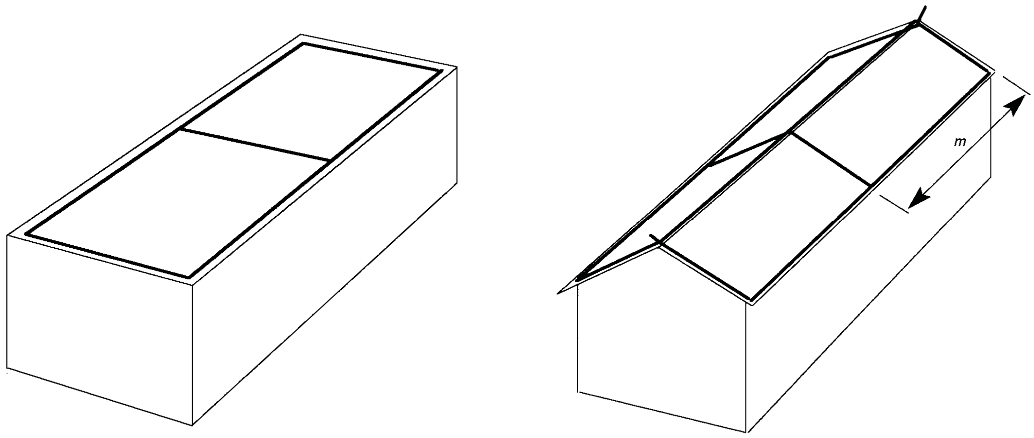
b) The lateral surfaces of the building at levels higher than the value of the radius of the relevant rolling sphere, is equipped with air-termination systems;

c) The mesh dimensions of the air-termination network are not greater than the values given in table 802-8;

d) The network of the air-termination system is accomplished in such a way that the lightning current will always encounter at least two distinct metal routes to the earth air-termination; no metal installation protrudes outside the volume protected by air-termination systems;

e) The air-termination conductors follow as far as possible short and direct routes.

NOTE Example of an LPS using the air-termination mesh method design are shown in figure A.802-11 for a sloped-roof and a flat-roof buildings.



m -Mesh size (width) should be selected accoding to table 802-8

LPS air-termination on a flat-roof **LPS air-termination on a sloped-roof**

Figure A.802-11 Example of design of an LPS air termination according to the mesh method

A.802-2.1.4 Choice of the type of air-termination system

Three methods may be used for the design of an LPS. The choice of a certain type of LPS depends on a particular evaluation of its suitability and the vulnerability of the building to be protected. However the choice of the type of air-termination system, should be based on the following considerations:

- An air-termination system composed of rods is preferred for an isolated LPS and for simple buildings of small dimensions or for small parts of large buildings. The height of non-isolated rods should be less than a few metres (2 m to 3 m) in order to avoid any increase in frequency of direct lightning flash. The rods are not suitable for buildings higher than the radius of the rolling sphere relevant to the selected protection level of the LPS;
- An air-termination system composed of stretched wires can be preferred in all previous cases and for short, long shaped buildings;
- Air termination systems composed of meshed conductors are for general purpose.

A.802-3 Design of down-conductors

A.802-3.1 General data

The choice of number and position of down-conductors should take into account the fact that, if the lightning current is shared in several down-conductors, the risk of side flash and of electromagnetic disturbances inside the structure is reduced. It follows that, as far as possible, the down-conductors should be uniformly placed along the perimeter of the structure and with a symmetric configuration.

The current sharing is improved not only by increasing of the number of down-conductors but also by equipotential interconnecting rings.

It is recommended that down-conductors are placed as far as possible from internal circuits and metallic parts in order to avoid the need for equipotential bonding. Following conditions should be satisfied:

- The down-conductors must be as short as possible (to keep inductance as small as possible);

- The distance between down-conductors should not exceed values shown in table A.802-1 below;
- In the cantilevered structures the safety distance shall also be evaluated with reference to the risk of side-flashing to persons.

Table A.802-1 Average distances between down-conductors according to the protection level

Protection level	Average distance (m)
I	10
II	15
III	20
IV	25

A.802-3.2 Recommended number

The position and spacing of down conductors is often governed by architectural convenience. However, their number should be decided in general according to the building base area as indicated below, or in accordance with table A.802-1.

- A building having a base area not exceeding 100 m^2 may have only one down conductor.
- For a building having a base area exceeding 100 m^2, the number of down conductors should equal the smaller of the following:
  a) one, plus one for every 300 m^2 or part thereof in excess of the first 100 m^2; or
  b) one for every 30 m of perimeter.
- For buildings exceeding 30 m in height, the number of down conductors is given in the table A.802-2 apply:

Table A.802-2 Average distance between down-conductors according to the plane area

Areas (m^2) between	Number of down conductors
100 - 400	2
400 - 700	3
700 - 1000	4
1000 - 1300	5
1300 - 1600	6
1600 - 1900	7

A.802-3.2 Number of down-conductors for isolated LPS

A.802-3.2.1 If the air-termination system consists of rods on separate masts (or one mast), at least one down-conductor is needed for each mast. In the case of masts made of metal or interconnected reinforcing steel, no additional down-conductor is necessary.

A.802-3.2.2 If the air-termination system consists of stretched wires (or one wire), at least one down-conductor is needed at each wire end.

A.802-3.2.3 If the air-termination system forms a network of conductors, at least one down-conductor is needed for each supporting building.

A.802-3.3 Number of down conductors for non-isolated LPS

A.802-3.3.1 If the air-termination system consists of one rod, at least one down-conductor is needed. If the air-termination consists of individual rods, at least one down-conductor for each rod is needed.

A.802-3.3.2 If the air-termination system consists of stretched wires, at least one down-conductor is needed at each wire end.

A.802-3.3.3 If the air-termination system consists of meshed conductors, at least two down-conductors are needed, distributed around the perimeter of the building to be protected.

A.802-3.3.4 No bend of a conductor shall form an angle less than 90 degrees, nor shall it have a radius of bend less than 200 mm.

A.802-3.3.5 Conductors shall be permitted to be coursed through air without support for a distance of 1.0 m or less. Conductors that must be coursed through air for longer distances shall be provided with a positive means of support that will prevent damage or displacement of the conductor.

A.802-4 Design of earth termination system

A.802-4.1 General

The earth termination system shall have a suitable configuration to avoid values of step and touch voltages that conventionally are considered dangerous.

In order to disperse the lightning current into the earth without causing dangerous overvoltages, the shape and dimensions of the earth-termination system are more important than a specific value of the resistance of the earth electrode. However, in general, a low earth resistance not exceeding 10 ohms is required.

From the viewpoint of lightning protection, a single integrated building earth-termination system is preferable and is suitable for all purposes (i.e. lightning protection, low-voltage power systems, and telecommunication systems).

Two different configurations of earth-termination systems are allowed: type A and type B.

A.802-4.2 Type A arrangement

Type A earth termination system is composed of horizontal or vertical earth electrodes. Each down conductor is connected to at least one separate earth electrode. This type is suitable for an LPS with rods or stretched wires or for an isolated LPS.

Where there is a ring conductor, which interconnects the down-conductors, in contact with the soil, the earth electrode arrangement is still classified as type A if the ring conductor is in contact with the soil for less than 80 % of its length.

In a type A arrangement the minimum number of earth electrodes shall be two.

A.802-4.3 Type B arrangement

The type B earth termination system is preferred for meshed air-termination systems and for LPS with several down-conductors. This type of arrangement comprises either a ring earth electrode, external to the building, in contact with the soil for at least 80 % of its total length or a foundation earth electrode.

A.802-4.4 Positioning of earth electrodes

The external ring earth electrode should be installed out side the space to be protected at a depth of at lest 0.5 m and distributed as uniformly as possible to minimize electrical coupling effects in the earth.

It should be buried not closer than 1.0 m to the building walls in such a way to allow inspection and testing.

It is recommended that the first metre of a vertical earth electrode not to be regarded as being effective under frost conditions. For bare solid rock, only type B earthing arrangement is recommended.

Deep-driven earth electrodes can be effective in special cases where soil resistivity decreases with depth and where substrata of low resistivity occur at depths greater than those to which rod electrodes are normally driven. When the metallic reinforcement of concrete is used as an earth electrode, special care shall be exercised at the interconnections to prevent mechanical splitting of the concrete.

NOTE In the case of prestressed concrete, consideration should be given to the consequences of the passage of lightning discharge currents, which may produce unacceptable mechanical stresses.

The LPS designer and the LPS installer should select suitable types of earth electrodes and should locate them at safe distances from entrances and exits of a building and to the external conductive parts in the soil. The down-conductors should be located in accordance with clause 2.2 of SASO IEC 61024-1. The LPS designer and the LPS installer should make special provisions for protection against dangerous step voltages in the vicinity of the earth-termination networks if they are installed in areas accessible to the public.

A.802-5 Earth electrodes

A.802-5.1 General

Each down conductor shall terminate at an earth terminal dedicated to the lightning protection system.

Earth rod or electrode shall be not less than 15 mm in diameter 2.5 m long. Rods shall be copper-clad steel, solid copper, hot-dipped galvanized steel, or stainless steel. Rods shall be free of paint or other nonconductive coatings.

Electrical and telecommunication systems earth electrodes shall not be used in lieu of lightning earth rods. This provision shall not prohibit the required bonding together of earth electrodes of different systems.

A.802-5.2 Earth rod Terminations

The down conductor shall be attached to the ground rod by bolting, brazing, welding, or using high-compression connectors listed for the purpose. Clamps shall be suitable for direct soil burial.

The lightning ground rods for deep moist clay soil shall extend vertically not less than 3 m into the earth. The earth shall be compacted and made tight against the length of the conductor or ground rod.

In sand or gravel, two or more ground rods, at not less than 3-m spacing, shall be driven vertically to a minimum depth of 3 m below grade.

A.802-5.3 Earth ring electrode

A ground ring electrode encircling a building (see figure A.802-12) shall be in direct contact with earth at a depth of not less than 700 mm or encased in a concrete footing. The encased electrode shall consist of not less than six continuous meters of bare copper main size conductor. The down conductor(s) shall be permanently attached to the ground ring electrode by bolting, brazing, welding, or using high-compression connectors listed for the purpose.

NOTE Combinations of the earth rod electrodes and earth ring electrodes shall be permitted.

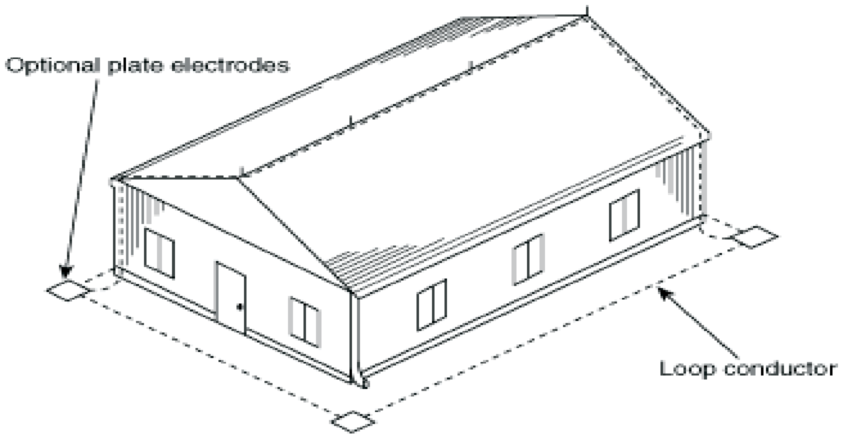
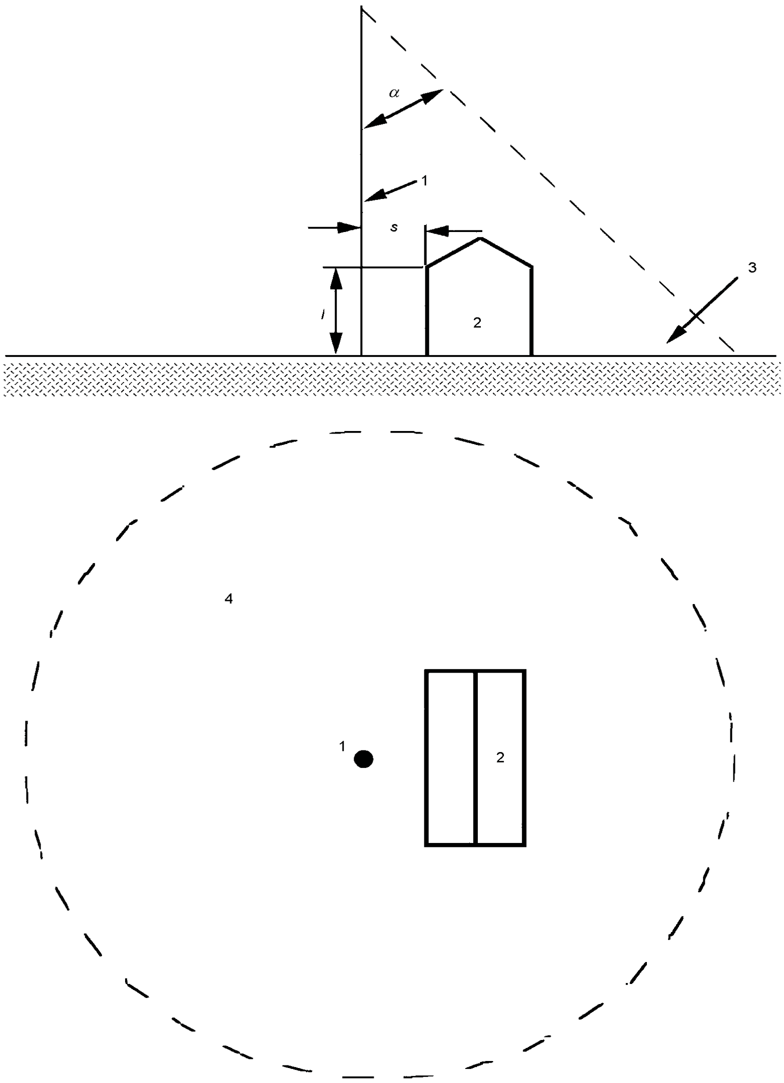


Figure A.802-12 Example of earth ring electrodes

Annex B.802

Example 1 of Isolated LPS

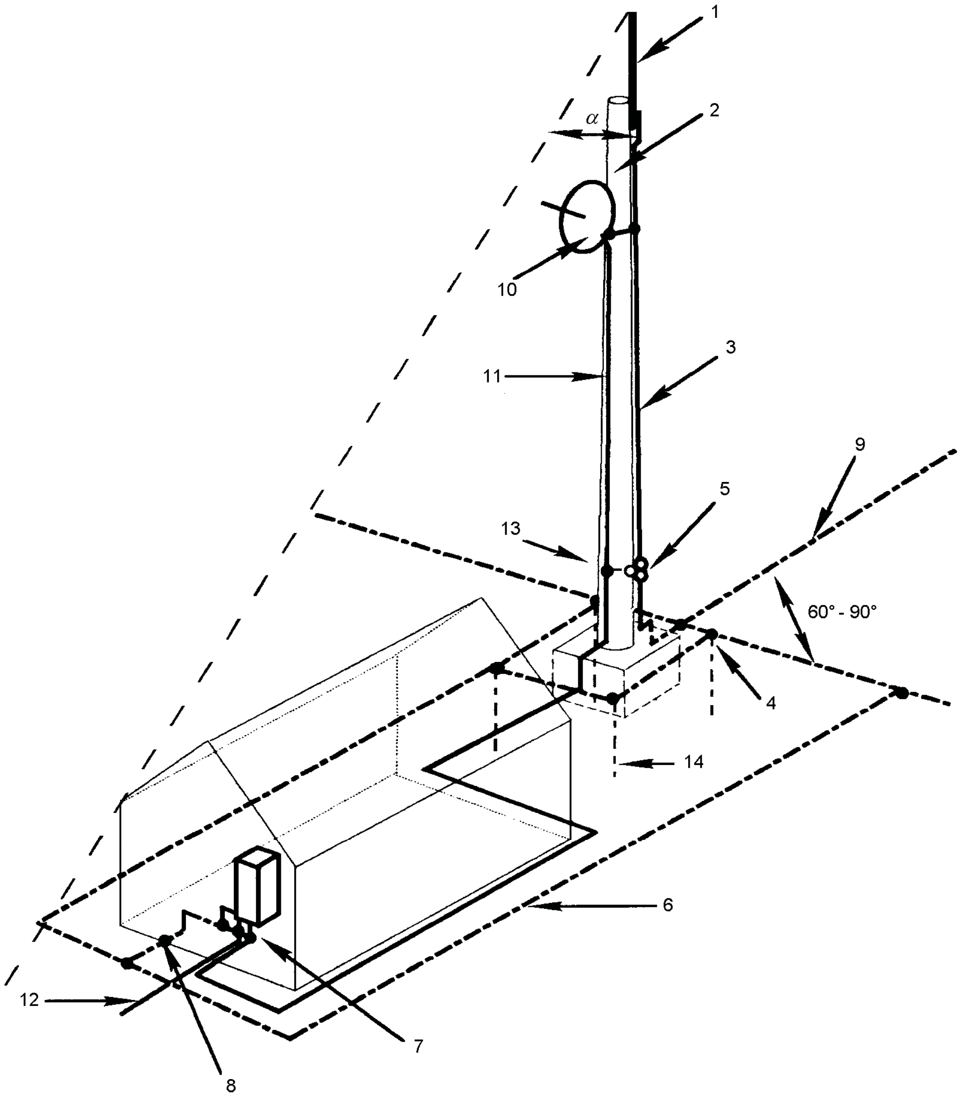


1 - Air-termination mast
2 - Protected structure
3 - Reference plane
4 - Protected area on the reference plane
L - Length for safety distance d evaluation
α - Protective angle
s - Separation distance according to 802-4.3.3

NOTE: The air-termination mast shall be designed and installed so that the whole structure is inside the protective cone of the mast.

Figure B.802-1 Example 1 of isolated LPS

Example 2 of Isolated LPS

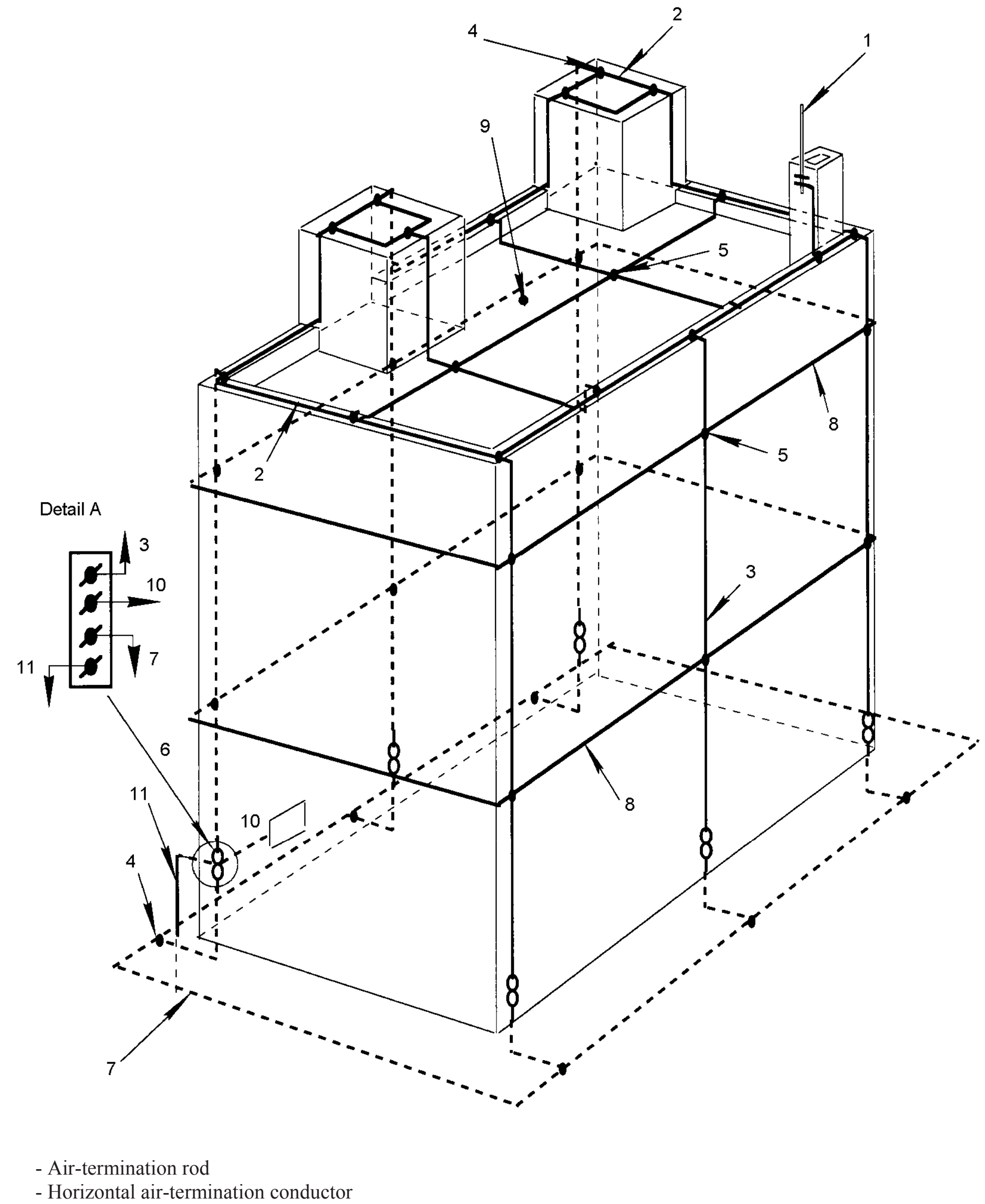


1 - Air-termination
2 - Air-termination mast
3 - Down-conductor
4 - Corrosion-resistant, T-type joint
5 - Test joint
6 - Earth electrode, type A earthing arrangement, radial earth electrode
7 - Vertical earth electrode, if applicable
s - Separation distance
α - Protective angle

NOTE: The separation distance s between the structure and the air-termination exceeds the safety distance according to 802-4.3.3.

Figure B.802-2 Example 2 of isolated LPS

Example 3 of non isolated LPS

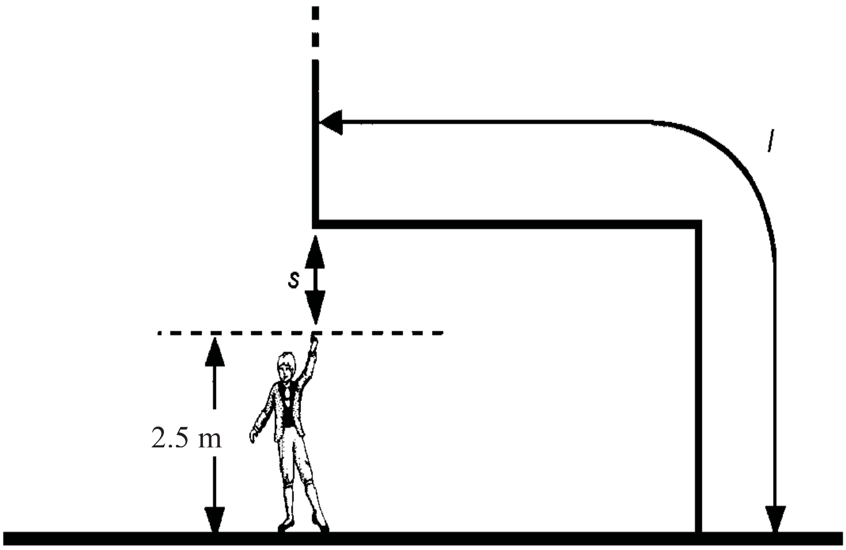


1 - Air-termination rod
2 - Horizontal air-termination conductor
3 - Down-conductor
4 - T-type joint
5 - Cross-type joint
6 - Test joint
7 - Type B earth electrode arrangement, ring earth electrode
8 - Equipotentialization ring conductor
9 - Flat roof with roof fixtures
10 - Terminal for connecting the equipotentialization bar of the internal LPS
11 - Terminal for connection A-type earthing electrodes

NOTE: An equipotentialization ring conductor is applied. The distance between the down-conductors complies with requirements in table A.802-1.

Figure B.802-3 Example of not isolated LPS

LPS for a cantilevered part of a structure



s separation distance according to 802-4.3.3

l Length for the safety distance *d* evaluation

NOTE: The height of the person with raised hand is taken to be 2.5 m.

Figure A.802-4 Design requirements for a cantilevered part of a structure

CHAPTER 803
FIRE DETECTION AND ALARM SYSTEMS

803-1 Scope

Since fire represents a great risk to humans and properties it was found necessary to incorporate in the Electrical Reguirements (SBC 401) a description on how to provide sufficient protection for the buildings against fire. Locations have to be classified according to level of risk, and the type of protection has to suit the type of location, and all of that has to be detailed in these Electrical Requirements.

However there is a complete requirement for fire protection and fire detection called SBC 800 and intended to be prepared by the fire committee. In SBC 800 a full description will be included to show how to and where this system has to be installed, therefore and to avoid any duplication it was found that it is better to keep the description of the requirements for fire detection and alarm in the intended code and to include in the Electrical Requirements only a reference to the main SBC 800.

This chapter contains the requirements for the electrical installations needed to supply power to fire detection and alarm systems.

For details of the requirements of the selection and erection of fire detection and alarm systems in new and existing buildings refer to SBC 800.

803-2 General requirements

The requirements for such electrical installations shall meet the following:

- a safety source shall maintain an electrical supply of adequate duration;
- equipment shall have a fire resistance of adequate duration either by suitable selection or erection.

803-3 Power supply

The primary and secondary power supply for the fire alarm system shall be provided in accordance with 55-6.5.1.

803-4 Wiring

Wiring shall comply with the requirements of the 55-6.6.

REFERENCED STANDARDS

The following normative documents contain provisions, which through reference in this text constitute provisions of these Electrical Requirements.
In case of no relevant Saudi Standards 'SASO', the latest version of IEC standards shall be applied.
SASO maintains registers of currently valid Saudi and IEC Standards.
The standards that are referenced in various sections of this document are listed herein by the promulgating agency of the standard and the standard identification.
The application of the referenced standards shall be as specified in SBC.

SASO STANDARDS

1. SASO, 35, Evaporative air coolers (Dessert coolers), Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
2. SASO, 112, Domestic electric fans, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
3. SASO, 113, Methods of test for domestic electric fans, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
4. SASO, 140, Testing methods for household electric clothes washing machines, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
5. SASO, 141, Household electric clothes washing machines, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
6. SASO, 182 (IEC 60038), IEC standard voltages, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
7. SASO, 232, Adhesive insulating tapes for electrical purposes, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
8. SASO, 254 (IEC 60614), Conduits for electrical installations – Specification (all parts), Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
9. SASO, 255, Plastic conduits and fittings for electrical installations, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
10. SASO, 269, Dry primary batteries, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
11. SASO, 386, Room air conditioners, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
12. SASO, 444, Plugs and socket-outlets for domestic and similar general use, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
13. SASO, 466, Electric lifts for passengers or goods – Part 1: General requirements, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
14. SASO, 467, Electric lifts for passengers or goods – Part 2: Safety requirements, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
15. SASO, 468, Electric lifts for passengers or goods – Part 3: Erection requirements, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
16. SASO, 482, Electric lifts for passengers or goods – Part 5: Safety measures for electrical installation of lifts, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
17. SASO, 490, Electric lifts for passengers or goods – Part 6: Acceptance, inspections and tests after installation in buildings, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.

18. SASO, 491, Electric lifts for passengers or goods – Part 7: Periodic inspection test, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
19. SASO, 531, Methods of test for storage-type electric water heaters for household use, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
20. SASO, 532, Storage-type electric water heaters for household use, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
21. SASO, 595, Rubber insulated cables of rated voltages up to and including 450/750 V – Part 1: General Requirements, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
22. SASO, 596, Rubber insulated cables of rated voltages up to and including 450/750 V – Part 2: Test methods, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
23. SASO, 597, Rubber insulated cables of rated voltages up to and including 450/750 V – Part 3: Heat resistant silicone insulated cables, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
24. SASO, 598, Rubber insulated cables of rated voltages up to and including 450/750 V – Part 4: Cords and flexible cables, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
25. SASO, 599 (IEC 60245-5), Rubber insulated cables of rated voltages up to and including 450/750 V – Part 4: Cords and flexible cables, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
26. SASO, 600 (IEC 60245-6), Rubber insulated cables of rated voltages up to and including 450/750 V – Part 6: Arc welding electrode cables, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
27. SASO, 751 (IEC 60228), Conductors of insulated cables, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
28. SASO, 752 (IEC 60332-1), Tests on electric cables under fire conditions – Part 1: Test on a single vertical insulated wire or cable, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
29. SASO, 980, Degrees of protection provided by enclosures (IP Code), Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
30. SASO, 1062, Safety of household and similar electrical appliances – Part 1: General requirements, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
31. SASO, 1274, Tests on electric cables under fire conditions – Part 3: Tests on bunched wires or cables, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
32. SASO, 1318, Luminaires – Part 1: General requirements and test, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
33. SASO, 1319 (IEC 60227-1), Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 1: General requirements, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
34. SASO, 1320 (IEC 60227-3), Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 3: Non-Sheathed cables for fixing wiring, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
35. SASO, 1321 (IEC 60227-5), Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 5: Flexible cables (Cords), Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.

36. SASO, 1346, Low-Frequency cables and wires with PVC insulation and PVC sheath – Part 2: Telephone wire for inside applications, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
37. SASO, 1349 (IEC 60898), Circuit-breakers for overcurrent protection for household and similar installations, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
38. SASO, 1603, Safety of household and similar electrical appliances – Part 2: Particular requirements – Section 35: Particular requirements for instantaneous water heaters, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
39. SASO, 1609 (IEC 60439-1), Low-voltage switchgear and contro lgear assemblies – Part 1: Type-tested and partially type-tested assemblies, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
40. SASO, 1610 (IEC 60439-2), Low-voltage switchgear and controlgear assemblies – Part 2: Particular requirements for busbar trunking systems (Busways), Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
41. SASO, 1611 (IEC 60439-3), Low-voltage switchgear and control gear assemblies – Part 3: Particular requirements for assemblies intended to be installed in places where unskilled persons have access for their use – distribution, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
42. SASO, 1612 (IEC 60934), Circuit-Breakers for equipment, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
43. SASO, 1613 (IEC 60050-826), International electrotechnical vocabulary. Electrical installations of buildings, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
44. SASO, 1614 (IEC 61024-1-1), Protection of structures against lightning – Part 1-2: General principles – Guide A: Selection of protection levels for lightning protection systems, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
45. SASO, 1672 (IEC 60570), Electrical supply track systems for luminaries, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
46. SASO, 1673 (IEC 60570-2-1), Electrical supply track systems for luminaries – Part 2: Mixed supply systems – Section 1: Classes I and III, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
47. SASO, 1674 (IEC 60598-2-1), Luminaires – Part 2: Particular requirements – Section one: Fixed general purpose luminaries, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
48. SASO, 1675 (IEC 60598-2-2), Luminaires – Part 2: Particular requirements – Section 2: Recessed luminaries, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
49. SASO, 1676 (IEC 60598-2-3), Luminaires – Part 2: Particular requirements – Section 3: Luminaires for road and street lighting, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
50. SASO, 1677 (IEC 60598-2-4), Luminaires – Part 2: Particular requirements – Section 4: Portable general purpose luminaries, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
51. SASO, 1678 (IEC 60598-2-5), Luminaires – Part 2: Particular requirements – Section 5: Floodlights, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.

52. SASO, 1679 (IEC 60598-2-6), Luminaires – Part 2: Particular requirements – Section 6: Luminaires with built-in transformers or convertors of filament lamps, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
53. SASO, 1680 (IEC 60598-2-7), Luminaires – Part 2: Particular requirements – Section 7: Portable luminaries for garden use, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
54. SASO, 1681 (IEC 60598-2-8), Luminaires – Part 2: Particular requirements – Section 8: Handlamps, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
55. SASO, 1682 (IEC 60598-2-9), Luminaires – Part 2: Particular requirements – Section 9: Photo and film luminaries (non-professional), Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
56. SASO, 1683 (IEC 60598-2-10), Luminaires – Part 2: Particular requirements – Section 10: Portable child-appealing luminaries, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
57. SASO, 1684 (IEC 60598-2-17), Luminaires – Part 2: Particular requirements – Section 17: Luminaires for stage lighting, television, film and photographic studios (outdoor and indoor), Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
58. SASO, 1685 (IEC 60598-2-18), Luminaires – Part 2: Particular requirements – Section 18: Luminaires for swimming pools and similar applications, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
59. SASO, 1686 (IEC 60598-2-19), Luminaires – Part 2: Particular requirements – Section 19: Air-handling luminaries (safety requirements), Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
60. SASO, 1687 (IEC 60598-2-20), Luminaires – Part 2: Particular requirements – Section 20: Lighting chains, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
61. SASO, 1688, Luminaires – Part 2: Particular requirements – Section twenty-two - Luminaires for emergency lighting, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
62. SASO, 1689, Luminaires – Part 2: Particular requirements – Section 23: Extra low voltage lighting systems for filament lamps, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
63. SASO, 1690 (IEC 60598-2-25), Luminaires – Part 2: Particular requirements – Section 25: Luminaires for use in clinical areas of hospitals and health care buildings, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
64. SASO, 1693 (IEC 60309-1), Plugs, socket-outlets and couplers for industrial purposes – Part 1: General requirements, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
65. SASO, 1694 (IEC 60502-1), Extruded solid dielectric insulated power cables for rated voltages from 1 kV (U_m = 1.2 kV) up to 30 kV (U_m = 36 kV) – Part 1: Cables for rated voltages of 1 kV (U_m = 1.2 kV) and 3 kV (U_m = 3.6 kV), Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
66. SASO, 1698, Safety of household and similar electrical appliances – Part 2: Particular requirements – Section 21: Storage water heaters, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
67. SASO, 1700 (IEC 60502-4), Extruded solid dielectric insulated power cables for rated voltages from 1 kV (U_m = 1.2 kV) up to 30 kV (U_m = 36 kV) – Part 4: Test requirements on accessories for cables with rated voltages from 6 kV (U_m = 7.2 kV) up

to 30 kV (U_m = 36 kV), Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.

68. SASO, 1702 (IEC 60227-5), Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 5: Flexible cables (Cords), Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
69. SASO, 1703 (IEC 60724), Guide to the short-circuit temperature limits of electric cables with a rated voltage not exceeding 0,6/1,0 kV, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
70. SASO, 1774 (IEC 60479–2), Effects of current passing through the human body. Part 2: Special aspects - Chapter 4: Effects of alternating current with frequencies above 100 Hz - Chapter 5: Effects of special waveforms of current - Chapter 6: Effects of unidirectional single impulse currents of short duration, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
71. SASO, 1890 (IEC 60227-7), Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 7: Flexible cables screened and unscreened with two or more conductors, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
72. SASO, 1891 (60949), Calculation of thermally permissible short-circuit currents, taking into account non-adiabatic heating effects, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
73. SASO, 1899 (IEC 60269-1), Low-voltage fuses – Part 1: General requirements, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
74. SASO, 1900, Common specifications for high-voltage switchgear and controlgear standards, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
75. SASO, 1901, Metal conduits and fittings for electrical installations, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
76. SASO, 1902, Methods of testing metal conduits and fittings for electrical installations, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
77. SASO, 1977, Safety of household and similar electrical appliances – Part 2: Particular requirements – Section 11: Tumble dryers, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
78. SASO, 1980, Aluminum-clad steel wires for electrical purposes, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
79. SASO, 1981 (IEC 60245-8), Rubber insulated cables of rated voltages up to and including 450/750 V – Part 8: Cords for applications requiring high flexibility, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
80. SASO, 1988, Low-voltage switchgear and control gear assemblies – Part 5: Particular requirements for assemblies intended to be installed outdoors in public places – Cable distribution cabinets (CDCs) for power distribution, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
81. SASO, 2010 (IEC 60331-11), Tests for electric cables under fire conditions – Circuit integrity – Part 11: Apparatus – Fire alone at a flame temperature of at least 750 °C, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
82. SASO, 2012, Emergency lighting systems in public buildings, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
83. SASO, 2015 (IEC 61046), D.C. or A.C. supplied electronic step-down converters for filament lamps – General and Safety requirements, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.

84. SASO, 2025, Safety requirements of household electric clothes washing machine and their methods of test, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
85. SASO, 2031, Safety of household and similar electrical appliances – Part 2: Particular requirements – Section 80: Fans, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
86. SASO, 2037 (IEC 60331-12), Tests for electric cables under fire conditions – Circuit integrity – Part 12: Procedures and requirements – Cables of rated voltage up to and including 0,6/1,0 kV, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
87. SASO, 2041, Low-voltage switchgear and control gear assemblies - Part 4: Particular requirements for assemblies for construction sites (ACS), Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
88. SASO, 2203, Plugs and socket-outlets for household and similar general use, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
89. SASO, 2204, Plugs and socket-outlets for household and similar general use, 127V, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
90. SASO, 2294, Tests on electric cables under fire conditions – Part 3-10: Test for vertical flame spread of vertically-mounted bunched wires or cables – apparatus, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
91. SASO, 2295, Tests on electric cables under fire conditions – Part 3-21: Test for vertical flame spread of vertically-mounted bunched wires or cables – Category a F/R, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
92. SASO, 2296, Tests on electric cables under fire conditions – Part 3-24: Test for vertical flame spread of vertically-mounted bunched wires or cables – Category C, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
93. SASO, 2433, Tests on electric cables under fire conditions – Part 3-22: Test for vertical flame spread of vertically-mounted bunched wires or cables – Category A, Saudi Arabian Standards Organization (SASO), P.O. Box 3437, Riyadh 11471, Saudi Arabia.
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